TAB J
PART 5

DATA CARRIER HAVING AN INTEGRATED CIRCUIT AND METHOD FOR PRODUCING SAME

This application is a continuation of application Ser. No. 752,072 filed as PCT EP84/00315 on Oct. 9, 1984, published as WO85/02046 on May 9, 1985 now abandoned.

The present invention relates to a multilayer data carrier comprising at least a core layer and an upper and lower cover layer, an IC module for processing electrical signals, and contact surfaces and leads for connecting the IC module with external devices, the IC module, contact surfaces and leads being arranged together on a substrate, the contact surfaces and leads being made of a thin electrically conducting coating of the substrate and the substrate being embedded between the core and cover layers in such a way that the IC module is located in a recess in the core layer and the contact surfaces are present in at least one recess in the upper cover layer.

Data carriers such as credit cards, identification cards and so on, which have an integrated circuit are increasingly used in automatic merchandise and service trade. Communication of the integrated circuit with corresponding machines is carried out in the most simple manner via galvanic contacting. For this purpose conductive coatings (contact surfaces) are provided on the card, which, on the one hand, are connected via leads with the circuit in the card and, on the other hand, allow for electrical connection with an external device via an appropriate contact head. The circuit itself is preferably disposed in the center of the identification card, while the contact surfaces are flush with the surface of the card. When designed in this manner, the contact surfaces can be kept free of contamination most simply during daily use of the card.

In the following, a few of the many identification cards having an integrated circuit and galvanic contacting which have become known already, shall be mentioned.

In German Offenlegungsschrift No. 26 59 573, the IC module is disposed on a flat, non-flexible substrate together with the leads and the contact surfaces. To incorporate the substrate into an identification card, the IC module is positioned in a recess in the card and the edges of the flat substrate connected to the card. Since the contact surfaces are disposed with the circuit on the same substrate, they are located, in the identification card, on the plane of the circuit, i.e. approximately in the center of the card. Access to the contact surfaces is thus possible only via depressions in the card surface. Since dirt tends to collect chiefly in these depressions, they are filled, as proposed in German Offenlegungsschrift No. 26 59 573, with a conductive material which is then flush with the surface of the card.

The raising of the contact surfaces, achieved by filling in the recesses in the card, may also be carried out separately from the production of the card during the production of the carrier substrate for the circuit.

In this connection German Offenlegungsschrift 30 29 667 must be mentioned, in which the contact surfaces of the carrier substrate or the carrier element are provided with electrically conductive bumps before being incorporated into a card. When the card is being completed, the carrier element is inserted into a window in this card and laminated with a cover film having recesses in the area of the bumps. The height of the conductive bumps corresponds to the thickness of the cover film, so that the contact surfaces are flush with the surface of the finished card.

The above-mentioned solutions have in common that the arrangement of the contact surfaces on the surface of the card requires additional procedural steps and additional material resources. Furthermore, due to the use of raised contacts in the known solutions, an additional transition point between the contact surfaces proper of the carrier substrate and the contact surfaces accessible on the finished card cannot be avoided, which basically creates an additional source of danger for disturbances.

This additional transition point can be avoided when the carrier element, as described in German Offenlegungsschrift No. 31 23 198, has bendable contact tags potruding freely beyond the edge of the carrier, which are directed through slits in the cover film and folded back when the card is put together. When the card layers are laminated under heat and pressure, the contact tags are pressed into the cover film and are flush with the surface of the finished card. Attention must be paid, in this method, that the relatively thin contact tags do not kink when they are directed through slits in the cover film. The proposed method is thus less suitable for mass production of identification cards with integrated circuits.

The problem on which the invention is based is therefore to propose an identification card having an IC module, in which the contact surfaces are located on the surface of the card while the module itself is mounted approximately in the center of the card. Unlike the known cards, this identification card should be easy and thus inexpensive to produce, so that it can be economically manufactured in large quantities. Furthermore, sources of danger which might disturb the operation of the IC module should be avoided to as great an extent as possible. Further, a method for production and a carrier element for an IC module to be incorporated into a data carrier are also proposed. In an advantageous embodiment of the invention, the IC module is mounted on a flexible carrier film having high thermostability and high tensile strength, the substrate. The circuit is connected in a recess in the substrate to leads which protrude into the recess. The leads end on the substrate in contact surfaces, the leads and contact surfaces being made of a thin, electrically conductive coating of the substrate. The contact surfaces are arranged, for example, collected into two groups on each side of the circuit on the substrate. The identification card comprises three layers. The middle layer or core layer is provided with a recess adapted to the circuit. The upper cover layer has two recesses or apertures which are punched congruently to the dimensions of the contact group.

While the card layers are being pressed together or laminated, the flexible substrate is deformed in such a way, essentially due to the recesses in the various layers of the card, that the module has a protected location in the center of the finished card, while the contact surfaces are flush with the surface of the card. The very simple card construction combined with the use of an equally simple and inexpensively produced carrier element comprising the substrate, the IC module, the leads and contact surfaces allow for the economic production of an identification card having an IC module, especially in large quantities. The material resources required for the known identification cards and, above all, the labor resources which in certain respects far exceed those in conventional card production, as explained above, are unnecessary in the case of the inventive card. Furthermore, it is ensured that the contact surfaces are

directly connected via leads to the circuit, thereby avoiding sources of danger for disturbances due to additional contacting or connecting points.

Further advantageous embodiments of the invention are characterized by different designs of the recesses in the upper cover film with respect to the contact areas of the carrier element, or by different techniques for attaching the carrier element in the card.

In the following, the embodiments and further advantages and developments of the invention shall be described in more detail with reference to the adjoined drawings.

These show:

FIGS. 1,2,3 identification cards with embedded IC modules in three different embodiments;

FIG. 4 the identification card as in FIG. 1 with a detailed view of the carrier element;

FIG. 5 the identification card as in FIG. 4 in cross-section before the various layers are joined together;

FIG. 6 the finished identification card in cross-section along the line 6—6 of FIG. 4;

FIG. 7 the finished identification card in cross-section along the line 7—7 of FIG. 4;

FIG. 8 a detailed view of a carrier element to be incorporated into an identification card as in FIG. 2;

FIG. 9 the identification card as in FIG. 2 in cross-section before the various layers are joined together;

FIG. 10 the finished card in cross-section along the line 10—10 of FIG. 8;

FIG. 11 a detailed view of a carrier element to be incorporated into an identification card as in FIG. 3;

FIG. 12 the identification card as in FIG. 3 in cross-section before the various layers are joined together;

FIG. 13 the finished identification card in cross-section along the line 13—13 of FIG. 12;

FIGS. 1, 2 and 3 each show an identification card having an integrated circuit disposed on a substrate, the position of the IC module and the contact surfaces, and the design of the apertures in the upper cover film of the card varying in each case. In the lower area of the card, the name of the card owner and a card number are printed, for example. For the sake of clarity, no further characters or printed patterns which are usual in such cards have been shown. In the following, the details of the identification cards shown in FIGS. 1, 2 and 3 shall be dealt with in connection with the description of the various embodiments.

FIGS. 4, 5, 6 and 7 show a first embodiment of the invention before and after the various vard layers are pressed together. The finished identification card corresponds to the card shown in FIG. 1. First, the construction of carrier element 2 shall be explained, which is shown from the top in FIG. 4 and in cross-section in FIG. 5. Carrier element 2 comprises IC module 3, leads 4, contact pads with contact surfaces 9 and substrate 10. IC module 3 is connected in a recess 11 in substrate 10 with the ends of leads 4 which protrude into the recess, and is held in the window solely by the attachment of the leads to the corresponding connection points in the module. This type of attachment or bonding of semiconductor elements with leads which are etched out of a conductive coating of the substrate has been known for some time and has proved its worth in practice (see also Siemens-Bauteile-Report 16 (1978), No. 2, pages 40–44).

In the case of the carrier element used for the inventive identification card, leads 4 end in contact surfaces 9 disposed on substrate 10, the dimensions of the leads being selected in such a way that direct contacting is possible in an automatic machine using a suitable sensing head. Four contact surfaces are arranged on each side of IC module 3 collected in groups. Substrate 10, which is made of flexible, thermostable and non-ductile material, for example polyimide, is punched in such a way that essentially only the area necessary for the contact surfaces and leads is underlaid by film material. The contact groups are connected via relatively narrow substrate webs 12 with the substrate area in which the IC module is disposed.

FIG. 5 shows the various elements of the identification card before the layers are laminated. Upper cover film 14 has approximately the thickness of substrate 10 including contact surfaces 9 and is provided with two apertures 17, 18. The apertures are dimensioned in such a way that they can each take up a group consisting of four contact surfaces. The middle card layer or core layer 13 has a recess 16 (see also FIG. 4) which is slightly larger than the IC module. Lower cover film 15 closes off the identification card on the back. When, as shown in this embodiment, substrate 10 is made of a material (such as polyimide) which does not connect with the material of the identification card (for example, PVC) when the layers are pressed together under heat and pressure, suitable elements must be provided to connect the different materials. In such a case, a so-called "fusion adhesive" in the form of a film 19 may be used. With the help of such an adhesive, different synthetic materials such as polyimide and PVC may be stuck to each other permanently under the effect of heat and pressure.

The layer construction shown in FIG. 5 is pressed together, as is usual in the case of conventional card production, using two steel plates 21, 22 under the effect of heat and pressure. In the initial phase of lamination, the pressure of the laminating plates acts predominantly on the points of greatest accumulation of material in the laminate. These are the areas indicated by dot-dash lines 24, 25, where lower cover layer 15, core layer 13, fusion adhesive film 19, substrate 10 and upper cover layer 14 are located one above the other. Due to this distribution of pressure, IC module 3 and the connection points of leads 4 with the IC module are initially relieved. In the course of lamination the fusion adhesive film softens, thereby form-fitting the geometrical structure formed by IC module 3, leads 4 and substrate 10. The card layers also soften subsequently. Since the material of substrate 10 does not soften in the range of the laminating temperatures, it is embedded between core film 13 and upper cover film 14 at the points indicated by lines 24, 25, displacing the softening card material. IC module 3 is pressed into recess 16 of core film 13 due to web 26 of cover film 14 located between apertues 17, 18, while the parts of substrate 10 provided with contact surfaces 9 give way and enter apertures 17 and 18 in upper cover film 14. During this phase, in which recess 16 of the core film is finally filled in with card material almost completely, the very soft fusion adhesive film 19 offers a protective buffer zone for IC module 3 and leads 4.

FIGS. 6 and 7 show the finished identification card. FIG. 6, a cross-sectional drawing along the line 6—6 of FIG. 4, clearly shows the deformation of substrate 10, which leads to IC module 3 having a protected location in the center of the card while contact surfaces 9 are flush with the surface of the card. Fusion adhesive 19 ensures reliable adhesion of substrate 10 to the card

especially in the area of contact surfaces **9** after the laminate has cooled off. FIG. 7, a cross-sectional drawing along the line **7—7** of FIG. **4**, shows that upper cover film **14** and core film **13** are connected with each other through recess **11** of substrate **10**, which is designed so as to be as large as possible, so that upper cover film **14** is firmly connected with the card core in the environment of IC module **3**. The already-mentioned relatively narrow connecting webs **12** between each contact group and the substrate area in which the IC module is located facilitate the deformation of the substrate.

In the following, a card, or the incorporation of a carrier element in a card, as already shown in FIG. 2, shall be described. In this embodiment all contact surfaces are located on one side of the substrate while the IC module is disposed on the other side. In this case relatively thick IC modules, for example, may be disposed in the area provided for high-embossing in the identification card, while the contact surfaces are located in the usual place so as to claim the area provided for embossing as little as possible.

FIG. **8** shows a carrier element **30** from the top, in which IC module **3** and contact areas **31** are separate. The IC module is disposed in a recess **32** in substrate **33** and held in this recess by self-supporting leads **4**. The leads connect IC module **3** with contact surfaces **31**. The number and arrangement of the contact surfaces depend on the IC module used, and may be adapted to the particular needs at hand. FIG. **8** shows by way of example an embodiment with **8** contact areas. In FIG. **8**, several small holes **35**, **38** may be seen distributed over substrate **33**, which serve to anchor the substrate between the various card films.

FIG. **9** shows the carrier element **30** described and the three card layers before assembly in a cross-sectional view along the line **10—10** of FIG. **8**. Core film **13** has a recess **16** in the area of IC module **3**, the periphery of this recess having virtually the same size as recess **32** in the substrate. The upper cover film has an aperture **17** in the area of the contact surfaces. this aperture being smaller than the substrate area bearing contact surfaces **31**. The lamination under the effect of heat deforms carrier element **30**, as shown in FIG. **10**, in such a way that the substrate area bearing the contact surfaces is shifted towards the surface of the card relative to the IC module, so that IC module **3** has a position in the middle of the card protected by the two card cover films **14**, **15** while contact surfaces **31** are flush with the surface of the card. It has turned out, surprisingly enough, that core film **13** embeds the edges of the substrate, on the one hand, and presses the contact areas up through aperture **17** to the outside surface of the layer construction, on the other.

Since the substrate has a large periphery in the area of the contact surfaces in comparison with recess **17** in upper cover film **14**, the edges of the substrate are anchored between upper cover film **14** and core layer **13**. In areas of the substrate which do not have any contact surfaces, for example the left-hand portion shown in FIG. **10**, the substrate is embedded between the core and upper cover films in any case.

The IC module is shifted downwards into recess **16** of core film **13** in the finished card. The expansion of leads **4** required for this change of position is braced by the diagonal design provided in the area of recess **32**.

It can be seen further in FIG. **10** that thermoplastic material of core film **13** and upper cover film **14** has flowed in in the area of holes **35** and connected itself. This intimate connection anchors the interjacent carrier element firmly in the card compound. Material of core layer **13** also flows through hole **38** in the area of the contact surface due to the applied pressure, until it is flush with the surface of the card.

Since recess **39** in the metallic contact surface is larger than hole **38** in the substrate, a plug with a T-shaped cross-section is formed, which connects the substrate additionally with the core film in the contact surface area. This embodiment is particularly advantageous when the contact area is large.

FIG. **11** shows a carrier element **40** which is chiefly suitable for a further embodiment. It is similar in many points to the carrier element described in detail in FIG. **4**. For example, IC module **3** is disposed in a recess **11** in substrate **10** and connected via leads **4** to contact surfaces **42**. The only difference is that the metallic contact surfaces **42** are not completely underlaid by substrate **10**. Dotted lines **41** indicate the recesses provided in the substrate under each contact surface.

FIG. **12** shows carrier element **40** in a cross-sectional view along the line **13—13** shown in FIG. **11** before incorporation into the card, together with the three card films. Core film **13** and upper cover film **14** exhibit the known recesses and apertures for taking up the IC module and contact surfaces. It is expedient for the described embodiment to underlay carrier element **40** with an adhesive layer **19** before it is incorporated into the card. The properties of this adhesive layer have already been described in detail above.

After core layer **13** has softened, substrate **10** is deformed towards the center of the card in the area of IC module **3**, while the thermoplastic material of the card gives way and enters apertures **17**, **18** in the upper cover film. In the process, metallic contact surfaces **42** are deformed towards the surface by the core material.

The expansion involved in the deformation is compensated by contact surfaces **42** designed as thin metal layers. In case the contact surfaces cannot compensate the expansion, for example using a relatively thick cover film, it must be ensured that the linear expansion is compensated in a different way. For example, the connection of the metallic contact surfaces **42** with substrate **10** can be designed in the edge area of the carrier element in such a way that this connection comes apart when subjected to tensile stress, making the metallic contact surfaces freely movable on one or more sides.

A further embodiment consists in leaving out a large area of substrate **10** across several contact surfaces **42**. For example, the contact areas of carrier element **40** shown in FIG. **11** may be underlaid only by narrow strips of substrate material on the outer longitudinal sides, or those facing the IC module, in order to obtain the same result as in the above-described embodiment.

In cases in which it is undesirable or impossible to apply the fusion adhesive, which is usually done under the effect of heat, the fusion adhesive may be replaced by a material in the form of a film or pieces of film, which is connected with the substrate by means of an adhesive effective at room temperature. This film material is selected in such a way that it is intimately connected with the card material during lamination under the effect of pressure and heat. Preferably, the same material is selected as was used for the rest of the layer construction, for example PVC. An advantage of this type of connection between the substrate and the card

layers is that the deformation of the carrier element can be effectively supported by selectively applying the film material to the areas of the carrier element which are to be deformed during lamination.

The carrier element described is exposed to different mechanical stresses both during production of the data carrier and during the use thereof.

The mechanical stresses acting upon the carrier element during lamination arise primarily in the areas of the carrier element which are deformed during the laminating process. The subsequent functioning of the data carrier can be adversely affected in particular by the mechanical forces acting upon the IC module or the leads.

The stresses acting upon the IC module during production of the card are taken care of according to the invention in the following manner. The compressive stresses present during lamination are kept away from the IC module due to its arrangement in a cavity in the layer construction so that no direct compressive stresses are applied to the IC module at least before the card material softens.

The mechanical stresses acting upon the leads provided between the IC module and the contact surfaces are also protected against tensile and deformation forces by special protective measures. The areas of the leads which are deformed during the laminating process are underlaid by thermostable materials with high tensile strength and firmly connected thereto in such a way that the forces arising during deformation are kept away from the sensitive leads and/or absorbed by the reinforcing material. The areas of the leads not underlaid by substrate, in the area of the recess in the substrate, are held in a stable position by a strip of the cover film during the laminating process so that the deformation forces are kept relatively small in this area.

As has been shown by extensive experiments, the mechanical stresses present during the use of the data carrier are mainly due to bending stresses in the longitudinal or diagonal direction of the card. The bending stresses acting in the direction of the width of the card are of less significance. Damage to the carrier element is prevented according to the invention by completely underlaying at least the leads extending in the direction of the main axes of stress, i.e. the longitudinal or diagonal direction of the card, with thermostable film material having high tensile strength, and firmly connecting them thereto. The areas of the leads which are not underlaid by substrate are preferably led toward the contacting points of the IC module parallel or along the short edges of the data carrier.

Depending on which applications the data carrier is produced for, the various types of stress can be selectively taken into account by specially designing the carrier element or specially designing the substrate and by arranging the contact surfaces, the leads and the IC module on the substrate accordingly. In the case of a carrier element as shown in FIG. 4 or FIG. 11, which is embedded in the data carrier as in the view of FIG. 1 or FIG. 3, both the mechanical stresses arising during production and those arising during the use of the card are taken into account in this way, for example. This kind of construction is recommended in particular for data carriers which are subjected to particularly strong mechanical stresses over a longer period of time.

The carrier element shown in FIG. 8 and incorporated into the data carrier in accordance with FIG. 2, on the other hand, primarily takes the stresses arising during the production of the card into account. This kind of construction may be particularly useful, influenced by various marginal conditions such as the addition of a magnetic stripe on the back of the card. It is completely safe in particular when the data carrier is exposed to stresses which are less strong during its subsequent use due to a shorter period of validity or more careful handling.

We claim:

1. A multilayer data carrier, such as a laminated card, comprising:
- a core layer including at least one recess;
- upper and lower cover layers on opposite sides of the core layer, at least said upper layer including at least one aperture;
- an IC module for processing electrical signals;
- a flexible, filmlike substrate having at least one recess;
- at least one contact pad having an integral contact surface area and a lead for connecting the IC module with an external device; said contact pad contact surface area and said lead comprising a thin, electrically conductive coating, said contact pad disposed on the substrate and said lead disposed at least in part on the substrate;
- said IC module disposed in the at least one recess of the substrate;
- said substrate embedded between the core and cover layers in such a way that the IC module is located in the recess in the core layer and the contact surface is located in said at least one aperture in the upper cover layer;
- said flexible substrate being deformed with portions of the substrate carrying the contact pad disposed so that the contact surface is flush with the surface of the upper cover layer and other portions of the substrate carrying the lead which establishes the contact to the IC module being deformed as by bending into a median plane of the data carrier.

2. A data carrier as claimed in claim 1, wherein
- several contact pads having contact surfaces from one contact field;
- said upper layer includes a plurality of apertures; the portions of the substrate carrying the contact field and the apertures in the upper cover layer have approximately the same configuration;
- the thickness of the upper cover layer is substantially equal to the thickness of the substrate including the contact surfaces, so that the contact field together with the corresponding portion of the substrate is completely bent into the apertures of the cover layer.

3. A data carrier as claimed in claim 2, wherein the portions of the substrate which carry the contact field are fixed on the core layer by means of a fusion adhesive.

4. A data carrier as claimed in claim 1, wherein the shape of the data carrier is rectangular, with opposed pairs of short and long edges;
- several contact pads having contact surfaces and leads to the I.C. module form an elongated contact field;
- some of said leads having portions extending parallel to the longer edges of the data carrier and portions extending parallel to the shorter edges of the data carrier;
- the substrate being oriented in the data carrier in such a way that the longer direction of the elongated

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contact field extends parallel to the shorter edges of the data carrier;

those portions of the leads which extend parallel to the longer edges of the data carrier being supported by said other portions of the substrate which are deformed as by bending into a median plane of the data carrier; and those portions of the leads extending parallel to the shorter edges of the data carrier establishing direct contact to the I.C. module and being unsupported at least in part by said other portion of the substrate in the median plane of the data carrier.

* * * * *

United States Patent [19]

Bernstein et al.

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[45] Date of Patent: Jan. 3, 1989

[54] PERSONAL MEMORY CARD HAVING A CONTACTLESS INTERFACE USING DIFFERENTIAL DATA TRANSFER

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[73] Assignees: **American Telephone and Telegraph Company**, New York, N.Y.; **AT&T Bell Laboratories**, Murray Hill; **AT&T Information Systems Inc.**, Morristown, both of N.J.

[21] Appl. No.: **856,171**

[22] Filed: **Apr. 28, 1986**

[51] **Int. Cl.**[4] **G06K 7/08**; G06K 19/06

[52] **U.S. Cl.** **235/487**; 235/380; 235/488; 235/492; 235/493

[58] **Field of Search** 235/492, 487, 488, 493, 235/451, 449, 441, 443, 380; 336/20; 375/36

[56] **References Cited**

U.S. PATENT DOCUMENTS

3,671,671	6/1972	Watanabe	375/36
4,007,355	2/1977	Moreno	235/492
4,277,837	7/1981	Stuckert	235/380
4,341,927	7/1982	Shinoi et al.	375/36
4,385,394	5/1983	Pace	375/36
4,473,825	9/1984	Walton	340/825.54
4,480,178	10/1984	Miller et al.	235/380
4,506,148	3/1985	Berthold et al.	235/380
4,605,844	8/1986	Haggan	235/492
4,650,981	3/1987	Foletta	235/380
4,654,512	3/1987	Gardosi	235/492
4,692,604	9/1987	Billings	336/20

FOREIGN PATENT DOCUMENTS

2542792	9/1984	France .	
2548803	1/1985	France .	
1152833	5/1969	United Kingdom .	
2149548	6/1985	United Kingdom .	
86/04171	7/1986	World Int. Prop. O.	235/492

OTHER PUBLICATIONS

IBM Technical Disclosure Bulletin, "Security Device Power Source", Abramson et al., vol. 17, No. 2, 7/74, pp. 492–493.

J. R. Lineback, "Are EEPROMS Finally Ready to Take Off?", Electronics, vol. 59, No. 7, pp. 40–41, 2-1-7-86.

Scientific American, "Smart Cards", by Robert McIvor, Nov. 1985, pp. 152–159.

Primary Examiner—Raymond F. Cardillo
Assistant Examiner—Robert A. Weinhardt
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[57] **ABSTRACT**

A personal memory card the size of a standard plastic credit card is usable in a variety of applications, from custom repertory dialing to storage of individual medical and/or banking records. Although the card looks and feels much like an ordinary credit card, the personal memory card includes a computer, an electrically erasable field-programmable read-only memory and also circuitry for inductively receiving a power signal and capacitive transferring data signals between the card and a card reader/writer located in an associated station. No direct ohmic electrical contact is made between the card and the reader/writer for transferring power to the card or for transferring data to and from the card. The card is also reprogrammable by the associated station with new and different data as desired.

19 Claims, 4 Drawing Sheets

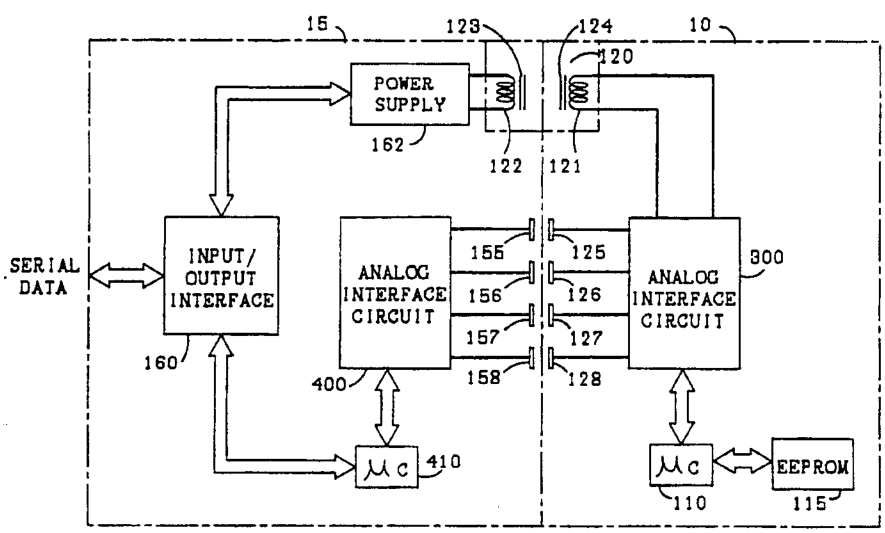

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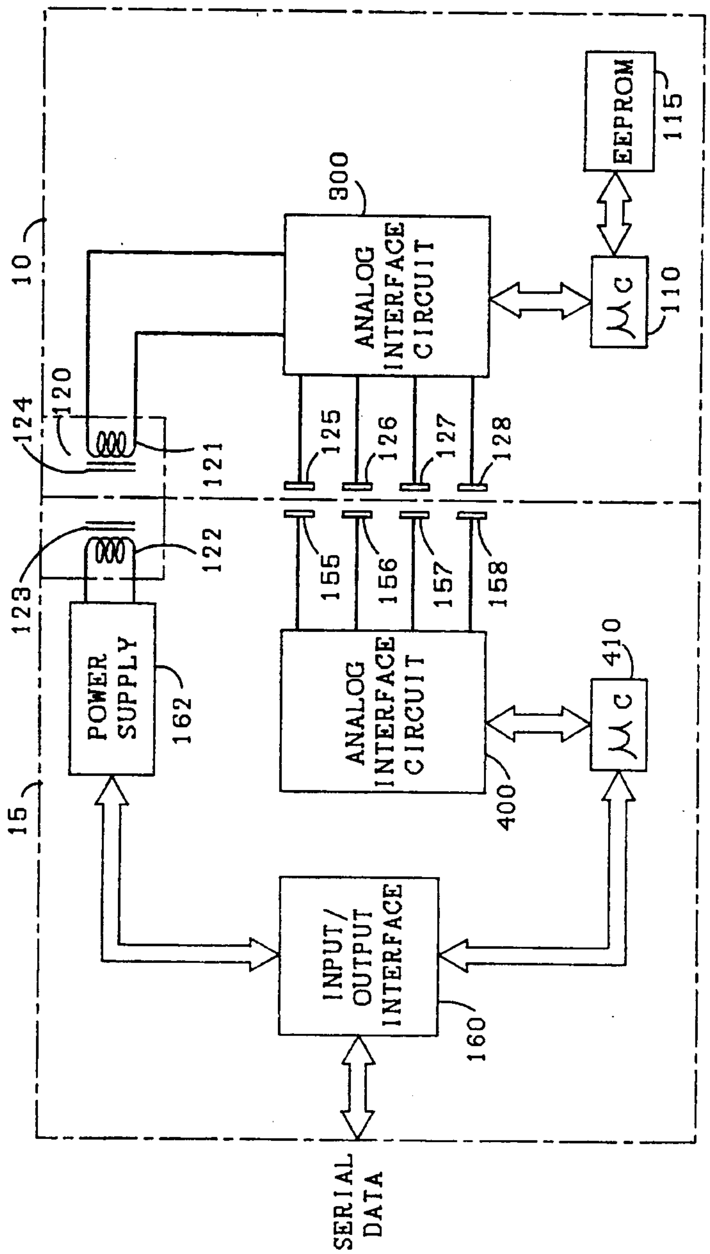
FIG. 1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EEPROM
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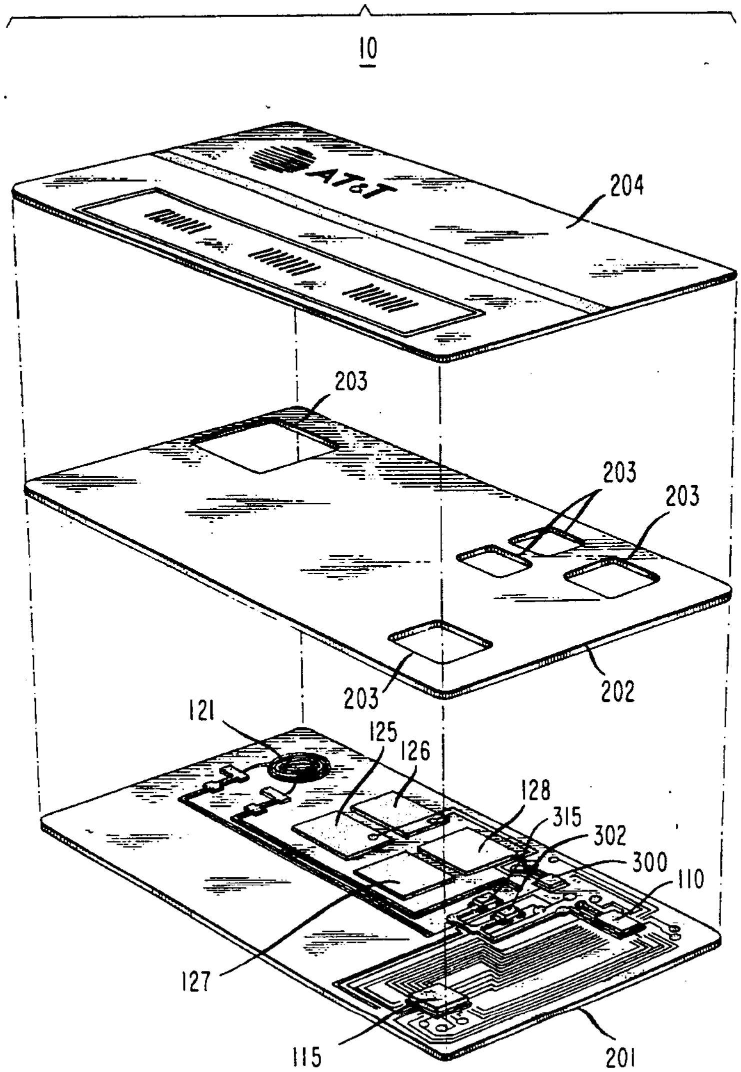
SERIAL DATA

FIG. 2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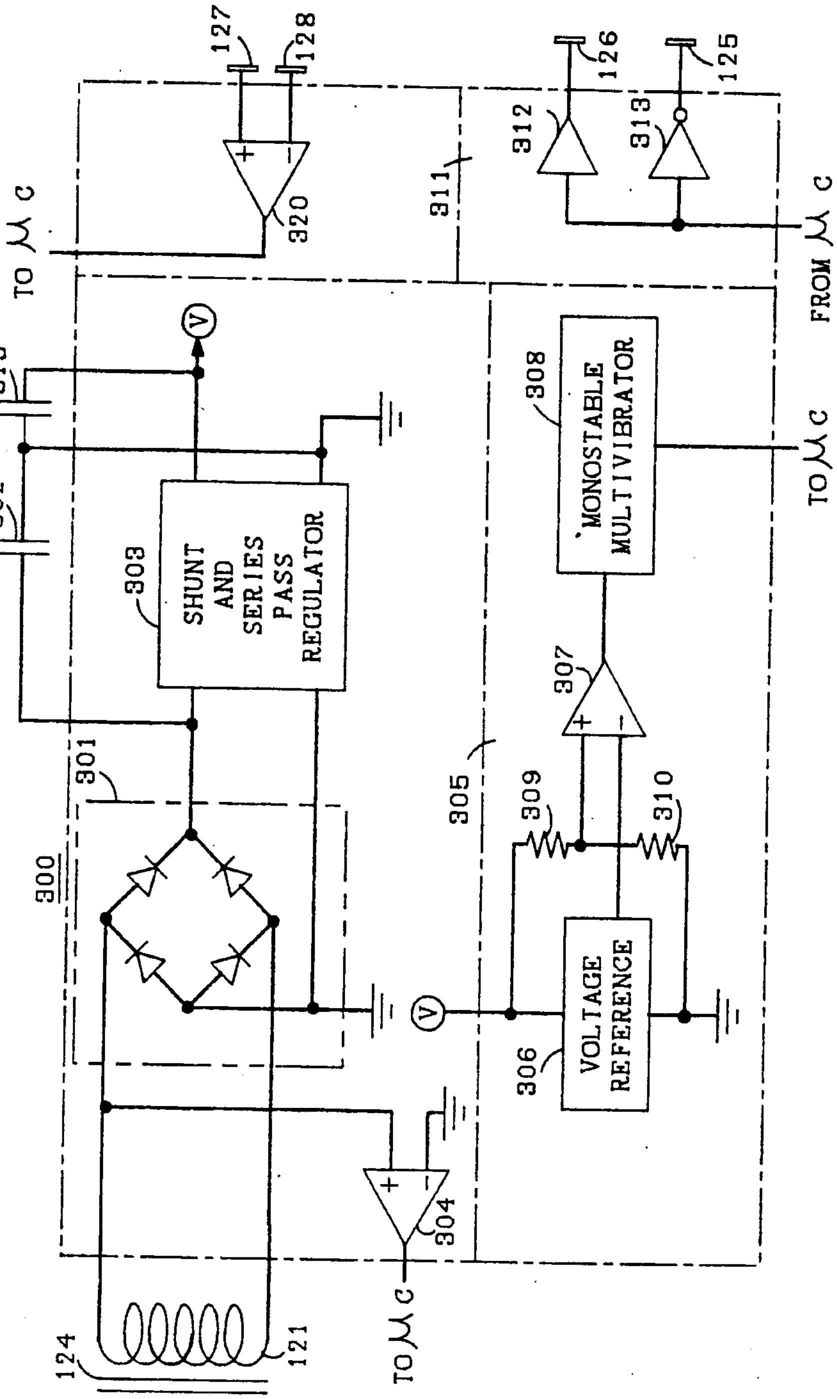
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FROM μC
V
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126
125
312
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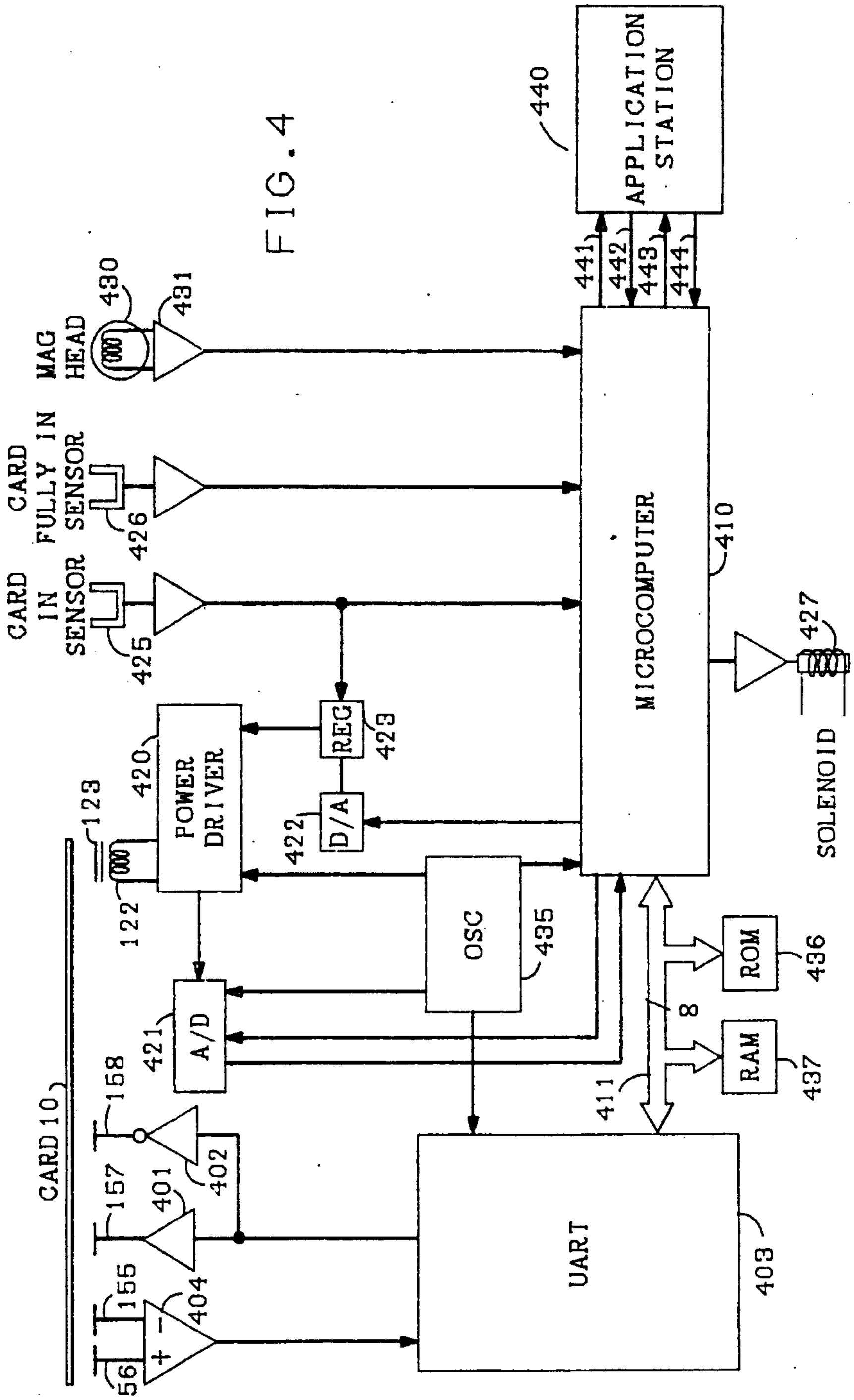
121

FIG. 3


APPLICATION STATION
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MAG HEAD
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CARD FULLY IN SENSOR
426
CARD IN SENSOR
425
MICROCOMPUTER
410
427
SOLENOID
POWER DRIVER
420
REG
423
D/A
422
123
122
OSC
435
ROM
436
RAM
437
8
411
A/D
421
CARD 10
158
157
155
156
401
402
404
+
-
UART
403

FIG. 4

PERSONAL MEMORY CARD HAVING A CONTACTLESS INTERFACE USING DIFFERENTIAL DATA TRANSFER

BACKGROUND OF THE INVENTION

This invention relates to smart cards and more particular to a smart card which interacts in a communication or processing system through a contactless interface.

DESCRIPTION OF THE PRIOR ART

The use of credit cards for purchases and for banking and other transactions has become so popular that most travelers today do so with very little cash. The card, typically made of plastic embossed with an account number and the name of the account owner, serves solely to identify an authorized account at a bank or credit house to be charged for a transaction. A magnetic stripe on the back of some cards contains the same information, but is machine-readable to speed the transaction. All accounting information is stored at the bank or credit house.

In that transactions generally occur at a location remote from the bank or credit house, it is easy for a person to use a misappropriated card, or for a legitimate owner to inadvertently exceed his credit limit. Most merchants, therefore, require that before purchases above a relatively modest amount such as $50.00 are completed, the authorization must be verified with the bank or credit house as appropriate. Even with automatic telephone dialing, the procedure is cumbersome and time-consuming. Furthermore, a separate card is needed for each account.

With the advent of recent advances in microelectronics, however, it is now possible to put a vast amount of computing power and memory right in the card to produce a "smart card" or "personal memory card". The card could, therefore, carry personal identification data to virtually eliminate fraudulent use—such data as personal characteristics, driver license, social security number, personal identification numbers, and even a voice print. The card could also carry the account numbers of all of the owner's charge accounts, the balances of all of the accounts, the credit limits of all of the accounts, and other such personal data as, for example, the sizes of family members for clothing purposes, personal telephone directories, etc. The types of personal data are limited only by one's imagination.

The technology for putting all of this on the standard size card is here. What is holding up this very convenient card, however, is what at first appears to be the mundane problem of a suitable interface for suppyling operating power to the card and reliably coupling data to and from the card.

Smart cards known in the art are being read and written into by various contact methods. One problem that arises if metallic contacts are used, however, is increased ohmic resistance due to the oxidation that takes place over time on the contact surfaces. This is of concern since the accuracy of the data transfer between a card and a reader or writer device decreases as the ohmic resistance of these contacts increases. In addition, the contacts, while in the exposed position, allow air-borne particles to deposit on the surfaces decreasing the contact area and causing intermittent connections. Inasmuch as operating power for reading and writing into a card is also transferred from an associated station in a system to the card via these contacts, there is a loss in the amount of energy transferred after some time of use, rendering the card inoperative.

A second problem associated with the use of metallic contacts in providing operating power and data onto the smart cards is the possibility of electrostatic discharge (ESD) occurring which can damage the microelectronics on the card. High voltages that build up on a person or card or that are inadvertently coupled thereto from other sources may very easily be coupled directly to the electronics on the card when metallic contacts are used. Clamping diodes employed at the various inputs of a card provide some measure of protection, but are not capable of protecting against some of the higher voltage levels a card might occasionally encounter during normal use in its expected environment.

SUMMARY OF THE INVENTION

In accordance with the invention, a personal memory card typically the size of a standard plastic credit card may be used in a variety of applications, from custom repertory dialing to storage of individual medical and/or banking records. Although the card looks and feels much like an ordinary credit card, the personal memory card includes a computer, an electrically erasable field programmable read-only memory, and also circuitry for receiving a combined power and timing signal and for receiving and transmitting data signals between the card and a reader/writer located in an associated station. No direct ohmic electrical contact is made between the card and the reader/writer for transferring power to the card or data to and from the card. Power to the card and data to and from the card are therefore reliably transferred even after some time of use. In addition, the potential of damage from electrostatic discharges to electronics in the card is minimized since an insulator in the form of a dielectric is provided between the conductors on the card and any sources from which this discharge might occur. The personal memory card is also selectively reprogrammable by an authorized user at the associated station with new and different data as desired.

BRIEF DESCRIPTION OF THE DRAWING

The invention and its mode of operation will be more clearly understood from the following detailed description when read with the appended drawing in which:

FIG. 1 is a functional block representation of a personal memory card and a reader/writer operative in accordance with the principles of the present invention;

FIG. 2 shows the basic structure of the personal memory card and the placement of the major components thereon in accordance with the principles of the present invention;

FIG. 3 shows a schematic diagram illustrating in greater detail the major functional components of the analog interface circuit depicted in the memory card of FIG. 1; and

FIG. 4 shows a schematic diagram illustrating in greater detail the major functional components of the reader/writer of FIG. 1.

Throughout the drawings, the same elements when shown in more than one figure are designated by the same reference numerals.

DETAILED DESCRIPTION

Referring now to FIG. 1, there is shown a block diagram of a portable data or personal memory card 10 being employed with a card reader/writer 15 in accordance with the invention. Some of the principle components located in the card 10 are a microcomputer 110, an electrically erasable programmable read-only memory (EEPROM) 115, an analog interface circuit 300, the secondary winding 121 of a transformer 120, and capacitive plates 125 through 128.

The microcomputer 110 includes a central processing unit and memory units in the form of random-access memory and read-only memory. A microcomputer available from Intel Corporation as Part No. 80C51 may be used for microcomputer 110 with the proper programming. Operating under firmware control provided by its internal read-only memory, the microcomputer 110 formats data to the EEPROM 115 and to the reader/writer 15 via the analog interface circuit 300. The microcomputer 110 also interprets commands from the reader/writer received through the analog interface 300. In addition, the microcomputer 110 checks for errors in reading and writing data to the EEPROM 115 and in transmissions to and from the reader/writer 15.

By employing EEPROM 115 in the card 10, an authorized user has the ability to reprogram certain sections of the card while at an authorized associated application station with new and different data as desired. EEPROMS are available from a number of suppliers, many of whom are mentioned in an article entitled "Are EEPROMS Finally Ready To Take Off?" by J. Robert Lineback, Electronics, Vol. 59, No. 7, (Feb. 17, 1986), pp. 40–41. Data may be written to and read or erased from an EEPROM repeatedly while operating power is being applied. When operating power is removed, any changes made to the data in the EEPROM remain and is retrievable whenever the card 10 is again powered.

The analog interface circuit 300 provides a means for interfacing the memory card 10 to the reader/writer 15. This interface performs a multitude of functions including providing operating power from magnetic energy coupled from the reader/writer 15 to the card 10, and also coupling data between the reader/writer 15 and the microcomputer 110 in the card 10. Power for operating the card 10 is provided to the analog interface circuit 300 via an inductive interface provided by the secondary winding 121 of a transformer 120. This transformer is formed when this secondary winding in the card 10 is mated to a primary winding 122 in the reader/writer 15.

The transformer 120 may advantageously include a ferrite core 123 in the reader/writer for increased coupling between the transformer primary winding 122 and secondary winding 121. A second such core 124 may also be included in the transformer 120 and associated with the secondary winding 121 in the card for a further increase in coupling efficiency. In those arrangements where ample power is available and efficiency is not a consideration, one or both of these cores may be omitted. The use of a transformer for coupling power into a credit card was proposed by R. L. Billings in U.S. Pat. No. 4,692,604, dated Sept. 8, 1987, this patent and this pending application being commonly assigned to the same assignee.

Data reception to and data transmission from the card 10 are provided to the analog interface 300 by a capacitive interface comprising four capacitors formed when electrodes or plates 125 through 128 on the memory card 10 are mated with corresponding electrodes or plates 155 through 158 in the reader/writer 15. Two of these capacitors are used to transfer data to the memory card 10 from the reader/writer 15 and the remaining two are used to transfer data to the reader/writer 15 from the card 10. The combination of the inductive interface and the capacitive interface provides the complete communication interface between the reader/writer 15 and the memory card 10. The analog interface circuit 300 is shown in greater detail in FIG. 3 and further described in the accompanying description later herein.

The organization of some of the components in the reader/writer 15 functionally mirror those in the card. Such components are, for example, an analog interface circuit 400 and a microcomputer 410. In addition, the reader/writer 15 also includes a power supply 162 and an input/output interface 160. The power supply 162 is used to provide power and also to couple a clock signal from the reader/writer 15 to the card 10 through the transformer 120. The input/output interface 160 is principally a universal asynchronous receiver transmitter (UART) and may be advantageously included in the microcomputer 410. The UART is used for externally communicating with a suitably configured application station.

With reference to FIG. 2, there is shown the basic structure of the card 10 and the relative placement of the principal components thereon. The card generally comprises a laminated structure including a 0.005 inch thick single or double sided printed wiring board 201. Capacitive plates 125 through 128 are shown deployed on the top side of this printing wiring board, but it is understood that it is well within the capabilities of one skilled in the art to deploy these plates on the bottom or opposite side of the board as long as they are covered by a suitable insulator or dielectric sheet. Pads for bonding the analog interface circuit 300, microcomputer 110, EEPROM 115, transformer secondary 121 and surfacemounted capacitors 302 and 315 are located on the top side of board 201. The integrated circuits, i.e., the microcomputer 110, EEPROM 115 and analog interface circuit 300, are wire bonded and the capacitors are conductively epoxied to the printed wiring board 201. It is to be understood that other means of electrically connecting the integrated circuits to the printed wiring board 201 are known to those skilled in the art. Tape automated bonding is an example of one such means.

In the construction of the card 10, the printed wiring board 201 has laminated to it a structural member 202 which is approximately 0.020 inches thick. This structural member has multiple openings 203 to accommodate the physical size of the above mentioned components which are mounted to the printing wiring board 201. A potting material is subsequently applied in sufficient quantity in the openings 203 of the structural member 202 to cover the components located therein and build up the slightly depressed upper surface of each of these components to align with the topmost surface of the structural member 202.

A top cover sheet 204 is laminated to the structural member 202. To this cover sheet an appropriate label and logos are either affixed thereto or embedded therein. A dielectric sheet is also laminated to the bottom side of the double sided printed wiring board 201 thereby covering up the conductor leads (and possibly conductive plates) located on the lower side of this board that would otherwise be exposed. It is this lower

exterior side of the card that generally has instructions and also a magnetic stripe and signature panel as desired.

Referring next to FIG. 3, there is shown in greater detail the analog interface circuit **300** of FIG. 1. A number of functions for the memory card **10** are provided by this interface circuit, such as power rectification and regulation, transmitting data to and receiving data from the reader/writer **15**, obtaining a clock signal from the transformer secondary **121** for operation of the microcomputer **110** and also providing a power reset operation for resetting this microcomputer whenever power is removed and then reapplied to the memory card **10**.

Magnetically coupled from the reader/writer **15** through the transformer **120** to the secondary winding **121** is an approximate 1.8 megahertz AC signal. The output of this secondary winding **121** is applied to a full wave bridge rectifier **301**. The DC voltage generated by the bridge rectifier **301** is filtered by a capacitor **302** and then coupled into a two-part regulator **303** which has a shunt regulator section on the front end and a series pass regulator on the back end.

The shunt regulator serves to keep the current drawn out of the transformer secondary winding **121** fairly constant and thereby insures operation in an optimal area on the power transfer curve of transformer **120**. This is desirable, since if the power demand in the card **10** decreases, the shunt regulator section dissipates the extra power to keep the load constant on the reader/writer **15** and on the transformer secondary winding **121** which is receiving the AC power. And if the power demand goes up in the card because an operation that requires greater power is occurring, the shunt regulator section reduces its power dissipation when it detects the voltage decreasing. The current then passes through the series-pass voltage regulator and provides operating power for all of the other circuitry in the card. Capacitor **315** provides additional filtering to the DC output of the shunt and series pass regulator **303**.

A clock recovery circuit **304** is coupled to the secondary winding **121** of the transformer **120** for providing a clock signal suitable for operation of the microcomputer **110**. This circuit **304** comprises a comparator which differentially compares one side of the secondary winding **121** of the transformer **120** relative to the ground node of bridge rectifier **301**. The pulses that are provided are shaped by the comparator giving relative fast turn-on and turn-off times suitable for driving the microcomputer **110**.

A reset circuit **305**, comprising a voltage reference **306**, a comparator **307** and a monostable multivibrator **308**, monitors the regulated output of the shunt and series pass regulator **303**. This circuit inhibits the operation of the microcomputer **110** if the supply voltage at the output of the shunt and series pass regulator **303** is not within a predetermined operating range.

A resistor string comprising resistors **309** and **310** form a divider circuit which reduces the voltage coupled to the comparator **307** from the regulator **303**. And the voltage reference **306** sets a threshold voltage level corresponding to the minimum allowable of the required operating level which is then compared with the voltage from the resistor string in comparator **307**. In operation, as the voltage from the shunt and series-pass regulator **303** rises from zero, the voltage provided to the comparator **307** from the voltage reference **306** is higher than the voltage provided to the comparator from the resistor string and the microcomputer remains

reset. When the voltage from the shunt and series-pass regulator **303** rises above the minimum operating voltage, the output of the resistor string becomes higher than the voltage reference. The comparator **307** then switches states and the monostable multivibrator **308** provides a pulse of approximately 200 milliseconds in length to the microcomputer **110** which is enabled thereby and a processor contained therein starts running.

If some time after reaching the required operating level, the regulated voltage happens to dip below the threshold voltage level, the reset circuit **305** detects this decrease and again inhibits the microcomputer **110**. This insures against extraneous operations which might occur and in some way affect the data in the EEPROM **115**. The reset circuit **305** thus causes the microcomputer **110** to be inhibited whenever the voltage is less than the predetermined operating voltage and guards against improper operation of the card **10** in such low voltage state.

Such an incorrect voltage could occur possibly because the card **10** is not fully seated into the reader/writer **15** or if there is too much of a gap between the surface of the card **10** and the mating surface in the reader/writer **15** because of some obstruction lodged on either surface. And since any interruption of the voltage to the card also causes the reset circuit **305** to be activated, occurrences such as an interruption of AC power to the reader/writer **15**, or a user pulling the card **10** out of the reader/writer **15** at an inappropriate time will also cause the microcomputer **110** to be inhibited. Operation of the microcomputer **110** is resumed once the supply voltage returns to the proper operating level.

A data out drive circuit **311**, comprising driver amplifiers **312** and **313**, receiver serial data from the microcomputer **110** and differentially drive the capacitive plates **125** and **126** which, respectively, interface with the capacitive plates **155** and **156** in the reader/writer **15**. These drivers **312** and **313** convert the serial data from the microcomputer **110**, which is of one polarity, into a differential polarity such that for each transition of the signal from the microcomputer **110**, one of the drivers goes positive, while the other goes negative.

A data receive circuit **320** is comprised of a differential amplifier and is used in receiving differential data coupled to the capacitive plates **127** and **128** from capacitive plates **157** and **158** in the reader/writer **15**. This data from the reader/writer **15** is coupled to the microcomputer **110** in the card **10** for the appropriate processing. Hysteresis is built into the data receive circuit **320** such that a differential pulse greater than the hysteresis is all that is required to switch the output of the amplifier from a high state to a low state or from a low state to a high state. The hysteresis aids in preventing noise from causing false triggering of the data receive circuit by ignoring small differential noise signals and switching only on large differential data signals. Thus once the data receive circuit switches states, if there is no further input, it will remain in whatever state it is then switched into and not drift back to the other state.

Although ESD problems are minimized with a contactless card, the addition of protective diodes to clamp the voltage on the outputs of data drive circuits **311** and the inputs of data receive circuit **320** may be designed and included in the card circuitry. The design of such clamping circuits for clamping and also integrating

voltages to safe levels is well known and within the capability of those skilled in the art.

Referring next to FIG. 4, there is shown a schematic diagram illustrating in greater detail the major functional components of the reader writer 15 shown in FIG. 1. The memory card 10, shown schematically in FIG. 1 and graphically in FIG. 2, is shown in FIG. 4 in operable contact with the data and power couping components of the reader/writer 15. Power to the card is provided from the reader/writer 15 via the primary winding 122 of the transformer 120 formed when the secondary winding 121 in the card 10 is mated to the primary winding 122 in the reader/writer.

As earlier indicated, the transfer of data between the reader/writer 15 and the card 10 is provided by a capacitive interface formed when the plates 125 through 128 on the card are mated with corresponding plates 155 through 158 in the reader/writer 15. The reader/writer 15 has a number of components comparable in operation to those found in the memory card 10. Like the card 10, the reader/writer 15 includes a data-out drive circuit comprising non-inverting driver amplifier 401 and inverting driver amplifier 402. These amplifiers receive serial data from a UART 403 and differentially drive the capacitive plates 157 and 158 which interface with the capacitive plates 127 and 128 in the card 10. Data for the memory card 10 is transmitted to the UART in parallel arrangement over an 8-bit bus 411 from a microcomputer 410.

The reader/writer 15 also includes a data receiver circuit 404 which is comprised of a differential amplifier and is used by the reader/writer 15 in receiving data coupled to the capacitive plates 155 and 156 from the capacitive plates 125 and 126 in the card 10. This serial data from the card 10 is coupled to the UART 403 where it is reformatted into parallel data and then coupled to the microcomputer 410 over the 8-bit data bus 411. The microcomputer 410, through use of an internal UART reconverts the data into a serial format with start and stop bits before coupling the data to a particular application station 440 with which the card 10 and reader/writer 15 are configured to communicate.

The application station may comprise a number of configurations. It may be configured as a factory editing station, an office editing station, an issuer editing station, public telephone station, or any other station suitably configured for interacting with the card 10.

Circuitry for efficiently controlling the transfer of power into the card 10 is advantageously included in the reader/writer 15. A power driver 420 controls the power level that is transmitted into the primary winding 122 of the transformer 120. The power provided to the card 10 via the transformer secondary winding 121 is proportinal to the current in this transformer primary winding 122. The amount of power being provided to the card 10 at any given time by the driver 420 is sampled and the information provided to the analog-to digital converter 421. This converter provides to the microcomputer 410 a digital signal equivalent of the sampled analog power level. The microcomputer 410, in turn, adjusts the power transfer to the card 10 to the desired level with a signal provided to a digital-to-analog converter 422. The output of this digital-to-analog converter is coupled to a voltage regulator 423 which provides continually corrected drive power for the card 10 into the power driver 420. In this way, power into the card 10 is controlled to within the desired range for proper and efficient operation.

Using a card with the reader/writer 15 requires inserting the card in an accommodating slot in the reader/writer 15. In order to insure proper mating between the card 10 and the interface components within the reader/writer 15 and also to insure correct turn-on of the reader/writer circuitry, proximity sensors are located in the slot in the reader/writer 15. A card-in sensor 425 is located approximately half way in the card slot. This is an optical sensor with illuminating and detecting elements. A mechanical arm is arranged to interrupt an optical beam generated by thei illuminating element and being detected by the detecting element as the card progresses approximately half-way into the slot. This card-in sensor 425 provides a signal to the microcomputer 410 once a card is at the halfway point on its way in or on its way out of the station.

A card fully-in sensor 426 is comparable to the card-in sensor in operation, but is located in the innermost part of the card slot. This sensor informs the microcomputer 410 when the card is fully seated in the card slot.

The reader/writer 15 is conveniently designed to accommodate not only personal memory cards with reprogrammable microelectronics therein, but also cards that have only a magnetic stripe affixed thereto. Once a card is fully seated, a test is performed to determine if the card is a contactless personal memory card or a card having only a magnetic stripe. This test is initiated by having the microcomputer 410 apply power to the power driver 420. If current is drawn from the transformer primary winding 122, the reader/writer 15 assumes a memory card is in the slot. Otherwise, the reader/writer assumes that a magnetic stripe card occupies the slot.

Once the card is fully inserted and if determined to be a memory card based on the current drawn from the transformer primary 122, a solenoid 427 is activated by the microcomputer 410 in order to bring the communication interface in the reader/writer 15 in contact with the inserted card. The capacitive plates 155 through 158 and transformer primary 122 comprising this interface are mounted on a platen for deflectably positioning against the card by this solenoid in order to get the best capacitive and inductive coupling with the card. If the card fully-in sensor 426 is ever tripped because the card is partially pulled out, the solenoid 427 releases immediately so that the card can be easily withdrawn.

If the test for a memory card proves negative, the microcomputer 410 decides that the card just inserted is a magnetic stripe only card. The microcomputer 410 then provides an audible or visual signal to the user to remove the card. As the card is pulled from the slot, data on the magnetic stripe is read by a magnetic head 430, amplified by an amplifier 431 and then coupled into a serial input port on the microcomputer 410.

Included in the reader/writer 15 is an oscillator section 435. This section provides a clock signal for the microcomputer 410 and also provides an approximate 1.8 megahertz signal for the power driver 420. It is this signal that is detected by the clock recovery circuit 304 in FIG. 3 in order to provide a clock signal suitable for operating the microcomputer 110 in FIG. 1.

A clock signal for the data transfer circuitry is also provided by the oscillator section 435 to the UART 403. This signal sets the data transfer rate between the card 10 and the reader/writer 15 at approximately 19.2 kilobits per second. Such a data rate keeps the capacitive plates properly biased during the intervals between data bit transitions and thereby minimizes the suscepti-

bility to noise in the communication interface betwen the card and the reader/writer due to voltage drift.

The microcomputer **410** has additional memory in the form of an external random access memory (RAM) section **437** and an external read only memory (ROM) section **436**. For ease of updating or reprogramming, the ROM section may be easily replaced or augmented with an EEPROM section. Such an EEPROM section in the reader/writer **15** and/or in the station **440** is easily reprogrammed by data contained in a card when the card is brought in operable contact with the reader/writer **15**.

As earlier indicated, the microcomputer **410** communicates with the outside world via a serial data path to the station **440**. This data path includes a transmit lead **441** and a receive lead **442**. It also has an attention lead **443** which is activated by the card fully-in sensor **426**. Finally, it also includes a reset lead **444** which enables the station **440** to reset the reader/writer **15** and initialize it into a known state. Power to the reader/writer **15** is also supplied by the station **440**.

Many other modifications of this memory card are possible and may obviously be implemented by those skilled in the art without departing from the spirit and scope of the invention. An example of such a modification is a memory card operating in a system wherein data is communicated only from the memory card to a card reader. The memory card and/or an associated card reader are configured to have the minimal communication interface and microelectronics necessary to establish and maintain the flow of data from the card to the card reader. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A portable data card including memory means for storing data and processor means for processing data, the data card comprising:

input/output means operably connected to the processor means for communicating with at least one reader/writer station, the processor means interpreting commands and processing data from the reader/writer station, the processor means being operably connected to and communicating with the memory means and formatting data for transfer both to the reader/writer station and to the memory means, the input/output means including capacitive coupling means for differentially transferring data from the reader/writer station to the data card and from the data card to the reader/writer station;

energy coupling means for receiving magnetic energy transmitted from the reader/writer station and for converting the magnetic energy into electric energy for energizing the memory means and the processor means; and

the capacitive coupling means and the energy coupling means providing in combination a complete communication interface between the data card and the reader/writer station.

2. The portable data card as in claim **1** wherein the capacitive coupling means comprises a series connection between the portable data card and the reader/writer station, the series connection being formed by bringing into alignment in close proximity electrodes in the card and in the reader/writer station.

3. The portable data card as in claim **2** in which at least one of each two electrodes brought into alignment has a dielectric material affixed thereto so that the dielectric material is juxtapositioned between the electrodes.

4. The portable data card as in claim **1** wherein the memory means comprises electrically alterable programmable read-only memory that is modifiable when the data card is brought in operable contact with the reader/writer station.

5. The portable data card as in claim **1** wherein the energy coupling means comprises a flat multiturn coil of electrically conductive material and rectifier means connected to the coil.

6. The portable data card as in claim **1** wherein the input/output means comprises an analog interface circuit for coupling data between the capacitive coupling means and the processor means, the interface circuit including a first and a second amplifier for receiving serial data from the processor means and for differentially coupling this serial data to the capacitive coupling means.

7. The portable data card as in claim **6** wherein the capacitive coupling means comprises a first and a second electrode on the portable data card, the first and second amplifiers respectively being connected to the first and second electrodes for transferring the serial data from the processor means to the reader/writer station.

8. The portable data card as in claim **7** wherein the analog interface circuit further comprises a third amplifier for receiving differential data from the capacitive coupling means and for coupling this differential data to the processor means.

9. The portable data card as in claim **8** wherein the capacitive coupling means further comprises a third and a fourth electrode on the portable data card, the third amplifier being connected to both the third and fourth electrodes for transferring the differential data from the reader/writer station to the processor means.

10. The portable data card as in claim **9** wherein the analog interface circuit further includes timing means connected to the energy coupling means for deriving timing pulses related to the frequency of the transmitted magnetic energy for timing data transfer between the memory means and the processor means and between the data card and the reader/writer station.

11. The portable data card as in claim **10** wherein the processor means comprises a microcomputer.

12. A portable data card including memory means for storing data and processor means for processing data, the data card comprising:

means operably connected to the processor means for communicating with at least one reader station, the processor means interpreting commands and processing data from the reader station, the processor means being operably connected to and communicating with the memory means and formatting data for transfer both to the reader station and to the memory means the communicating means including capacitive coupling means for differentially transferring data from the data card to the reader station;

energy coupling means for receiving magnetic energy transmitted from the reader station and for converting the magnetic energy into electric energy for energizing the memory means and the processor means; and

the capacitive coupling means and the energy coupling means providing in combination a complete communication interface between the data card and the reader station.

13. The portable data card as in claim **12** wherein the capacitive coupling means comprises a series connection between the portable data card and the reader station, the series connection being formed by bringing into alignment in close proximity electrodes of the card and of the reader station.

14. The portable data card as in claim **13** in which at least one of each two electrodes brought into alignment has a dielectric material affixed thereto so that the dielectric material is juxtapositioned between the electrodes.

15. The portable data card as in claim **12** wherein the energy coupling means comprises a flat multiturn coil of electrically conductive material and rectifier means connected to the coil.

16. The portable data card as in claim **12** wherein the communicating means includes an analog interface circuit for coupling data from the processor means to the capacitive coupling means, the analog interface circuit including a first and a second amplifier for receiving serial data from the processor means and for differentially coupling this serial data to the capacitive coupling means.

17. The portable data card as in claim **16** wherein the capacitive coupling means comprises a first and a second electrode on the portable data card, the first and second amplifiers respectively being connected to the first and second electrodes for transferring the serial data from the processor means to the reader station.

18. The portable data card as in claim **17** wherein the analog interface circuit further includes timing means connected to the energy coupling means for deriving timing pulses related to the frequency of the transmitted magnetic energy for timing data transfer between the memory means and the processor means and from the data card to the reader station.

19. The portable data card as in claim **18** wherein the processor means comprises a microcomputer.

* * * * *

United States Patent [19]
Hida et al.

[11] Patent Number: 4,841,134
[45] Date of Patent: Jun. 20, 1989

[54] IC CARD

[75] Inventors: Yoshiaki Hida; Satoshi Ishihara; Seiji Take; Masao Gogami; Toshiyuki Suzuki, all of Tokyo, Japan

[73] Assignee: Dai Nippon Insatsu Kabushika Kaisha, Tokyo, Japan

[21] Appl. No.: 889,277

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[51] Int. Cl.[4] G06K 19/02
[52] U.S. Cl. 235/488; 235/492
[58] Field of Search 235/488, 492

[56] References Cited

U.S. PATENT DOCUMENTS

4,463,971	8/1984	Hoppe et al.	235/488 X
4,617,216	10/1986	Haghiri-Tehrani et al.	235/488 X
4,719,140	1/1988	Hara et al.	235/488 X

Primary Examiner—David L. Trafton
Attorney, Agent, or Firm—Arnold, White & Durkee

[57] ABSTRACT

The IC card of the present invention comprises an IC card comprising an IC module embedded in a card substrate, said IC card having a reinforcing sheet layer laid in the planar direction of the card so as to cover at least the peripheral portion of the boundary between the card substrate and the IC module, and/or has a reinforcing member comprising at least a part of the side portion of said IC module extended in the outer circumferential direction, and it is excellent in mechanical strength and flexibility against bending of card.

22 Claims, 20 Drawing Sheets

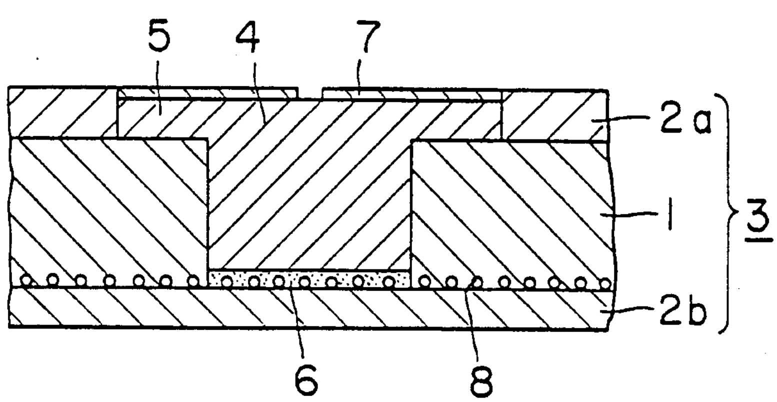


FIG. 1a

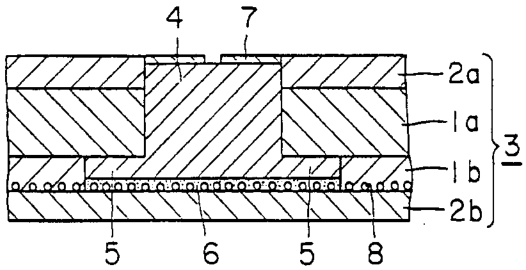


Fig. 1b

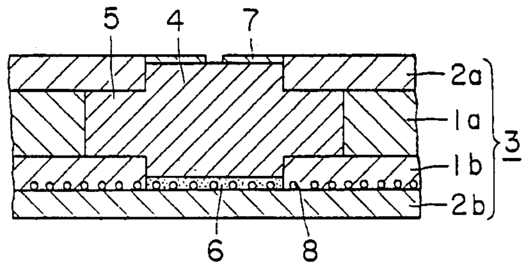


Fig. 1c

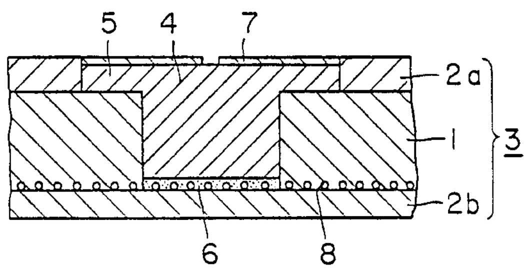
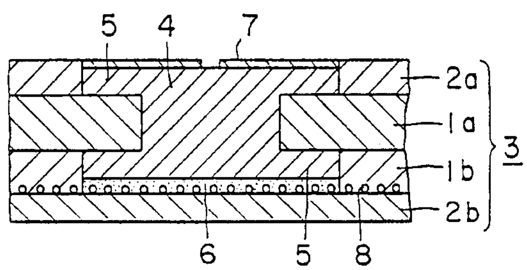


Fig. 1d



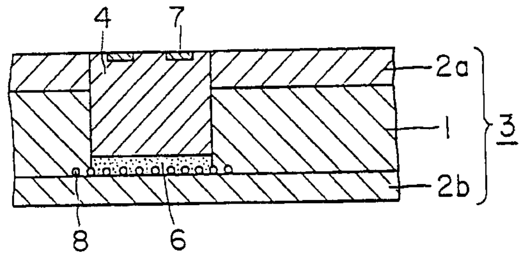


FIG. 1B

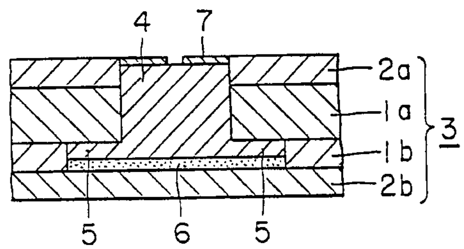


FIG. 1C

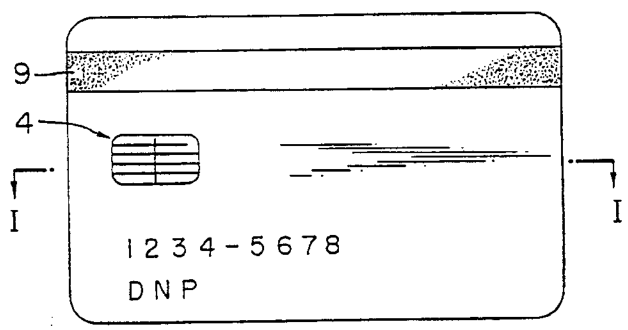


FIG. 2

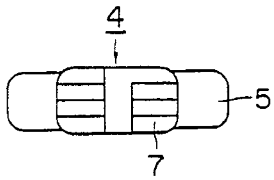


FIG. 3a

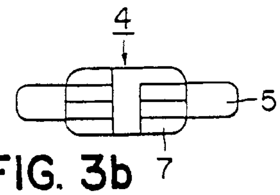


FIG. 3b

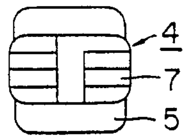


FIG. 3c

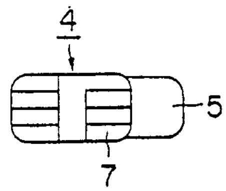
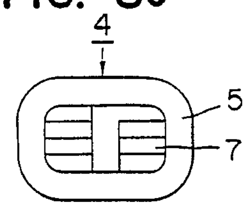


FIG. 3d



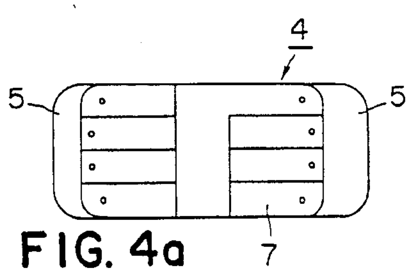


FIG. 4a

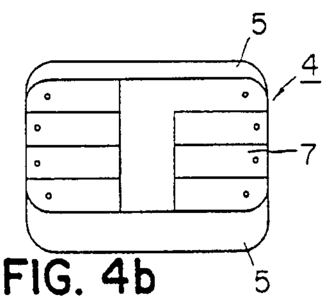


FIG. 4b

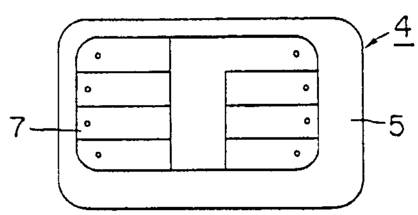


FIG. 4c

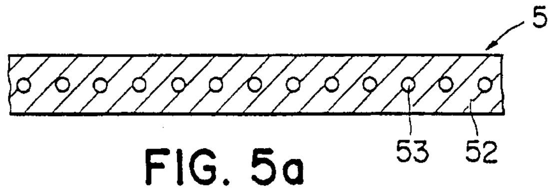


FIG. 5a

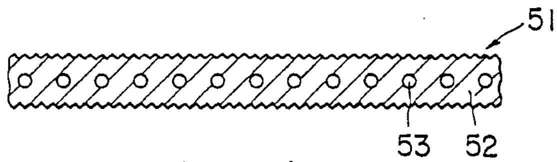


FIG. 5b

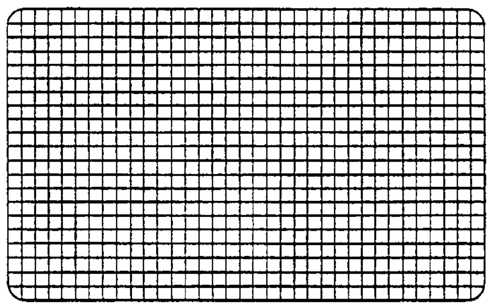


FIG. 6a

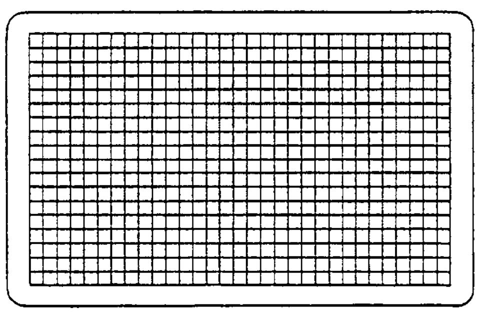
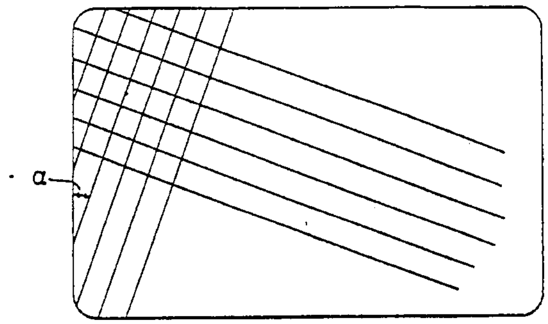
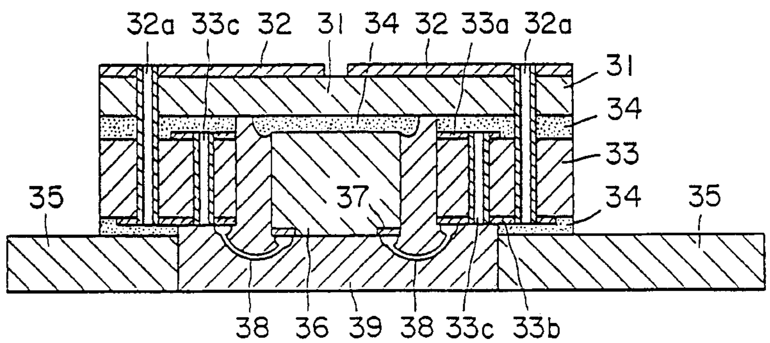


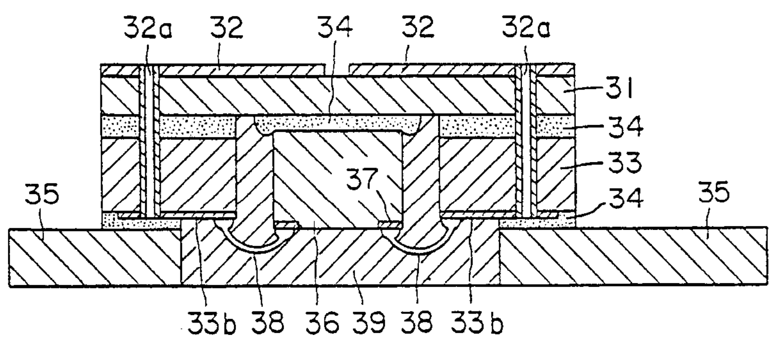
FIG. 6b



F I G. 7



F I G. 8 A



F I G. 8 B

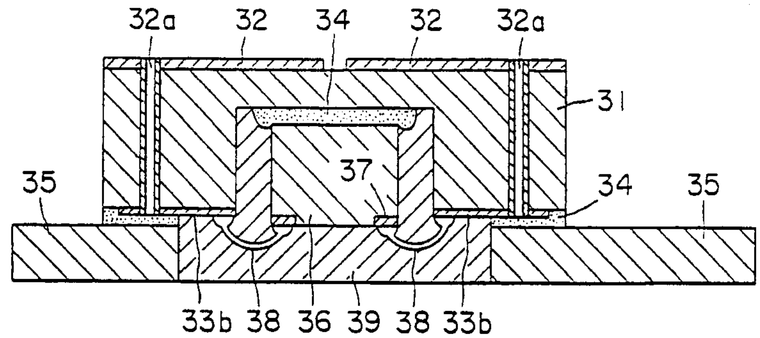


FIG. 8C

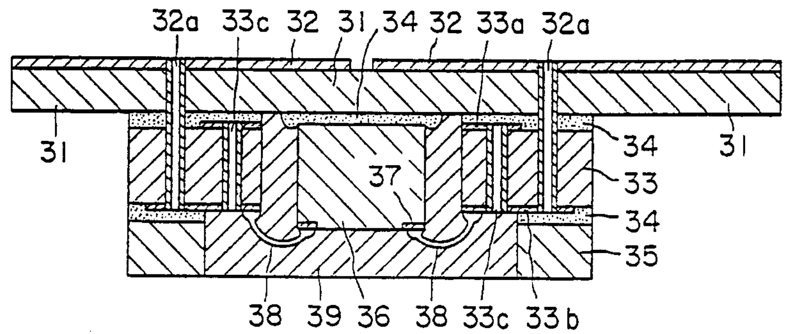


FIG. 9

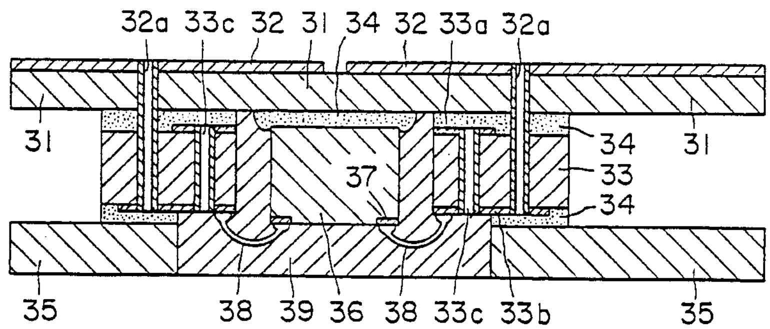


FIG. 10

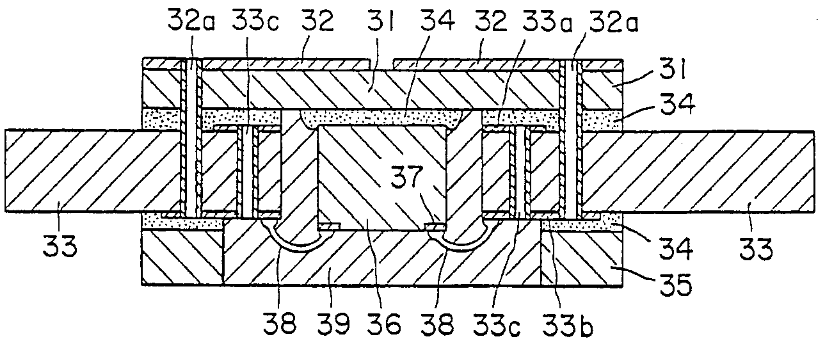


FIG. 11

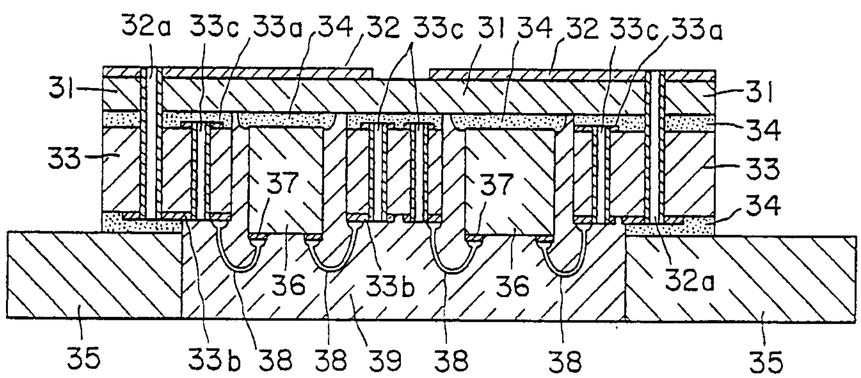


FIG. 12

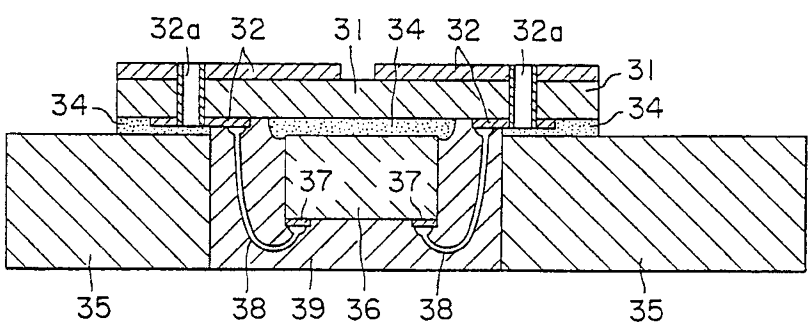
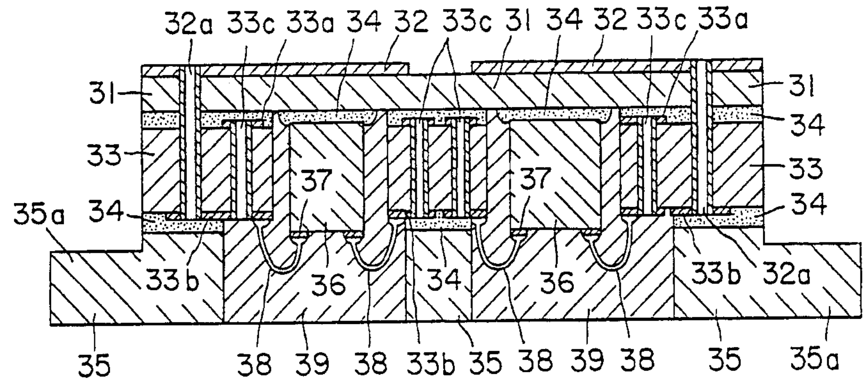
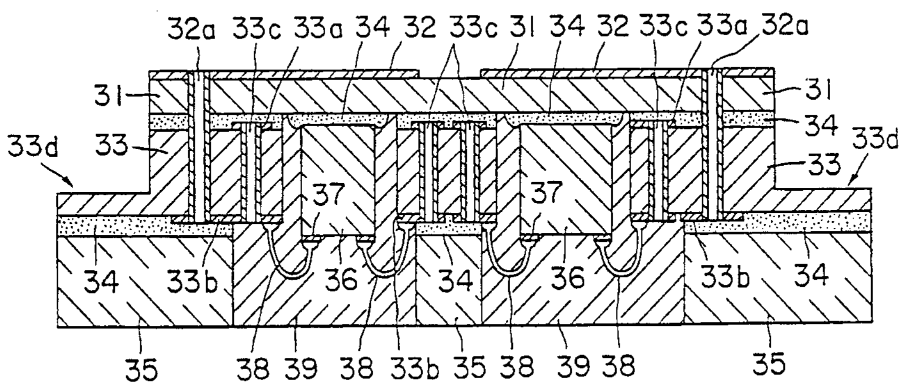


FIG. 13



F I G. 14



F I G. 15 A

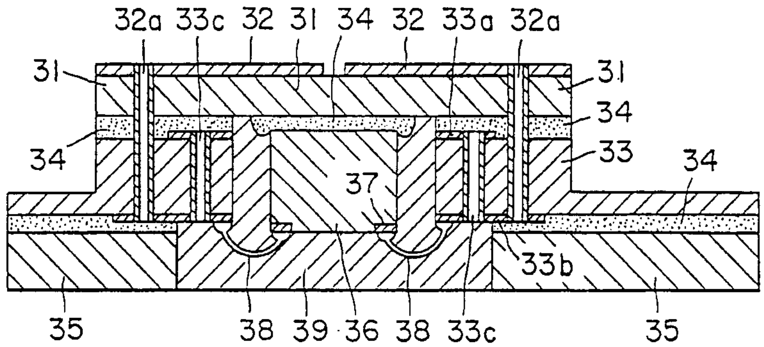


FIG. 15B

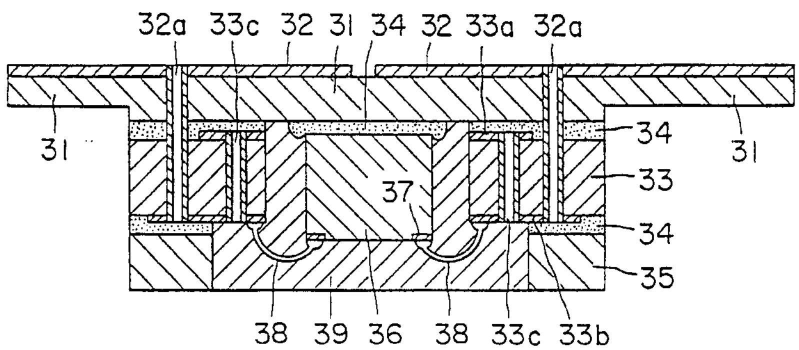


FIG. 15C

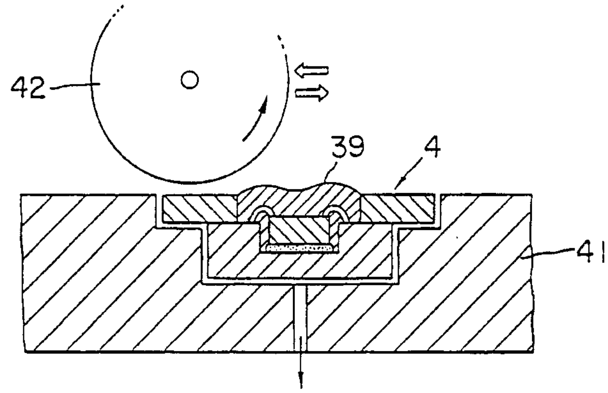


FIG. 16

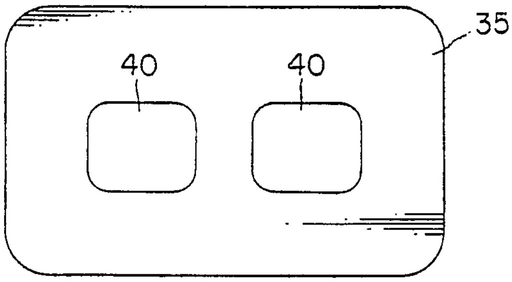


FIG. 17

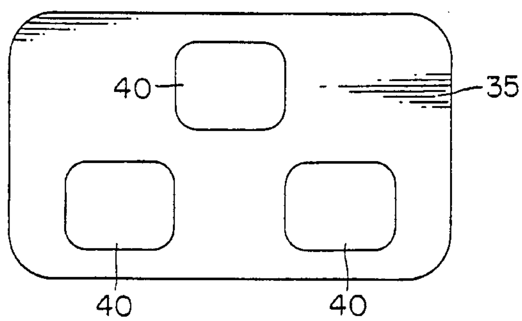


FIG. 18

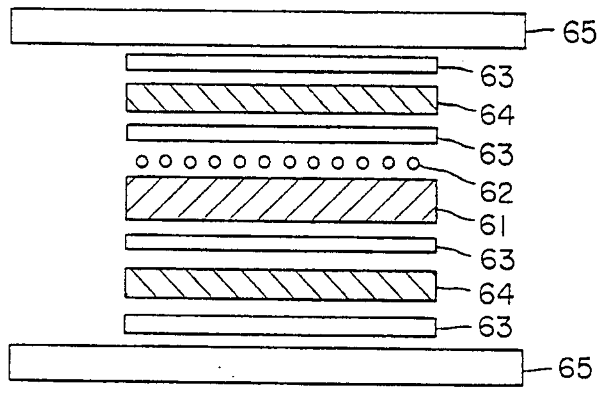


FIG. 19

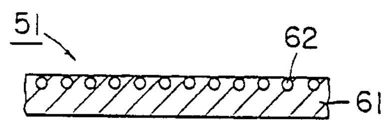


FIG. 20

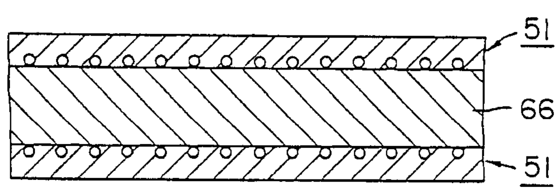


FIG. 21

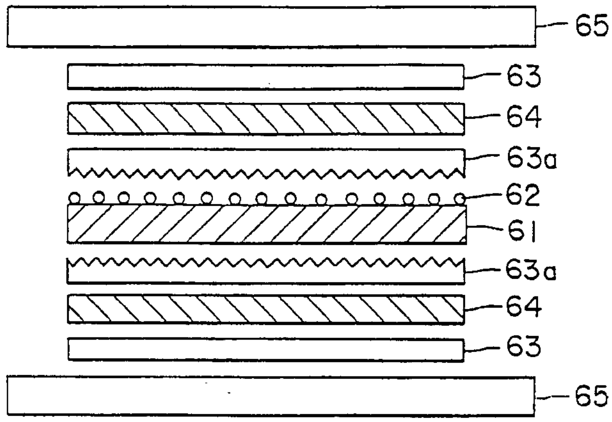


FIG. 22

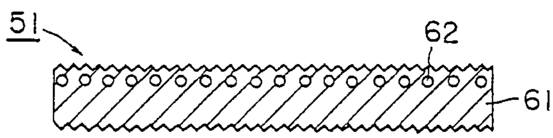


FIG. 23

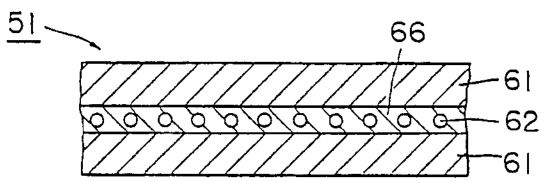


FIG. 24

FIG. 25a

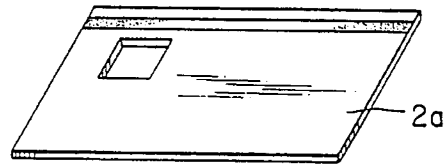


FIG. 25b

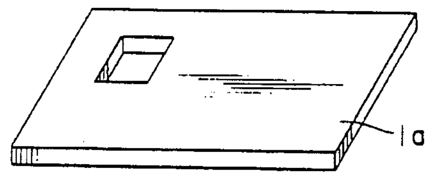


FIG. 25c

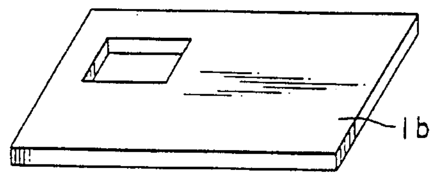


FIG. 25d

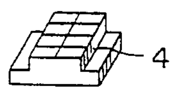


FIG. 25e

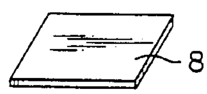


FIG. 25f

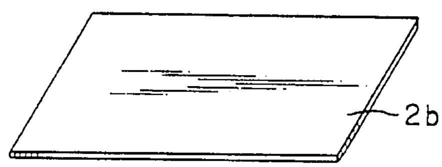


FIG. 26a

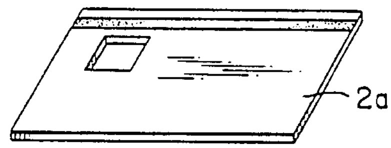


FIG. 26b

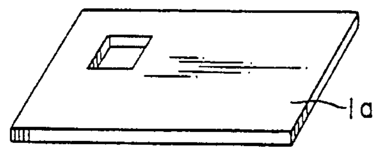


FIG. 26c

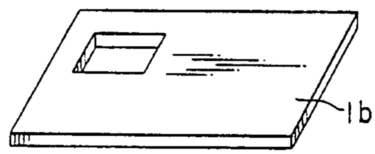


FIG. 26d

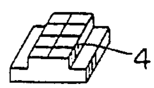


FIG. 26e

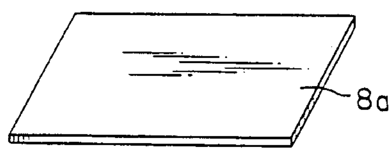


FIG. 26f

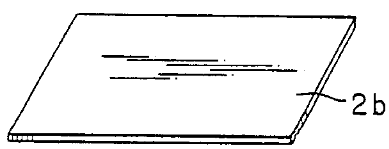


FIG. 27a

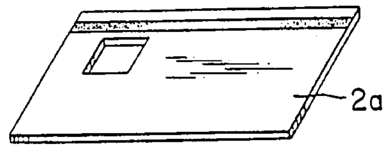


FIG. 27b

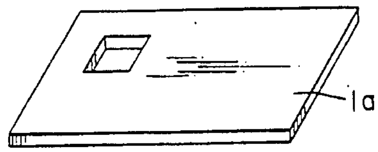


FIG. 27c

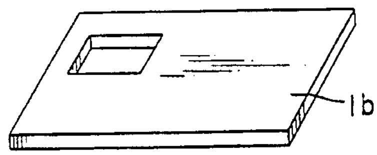


FIG. 27d

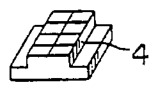


FIG. 27e

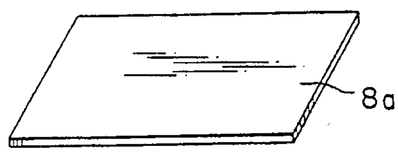
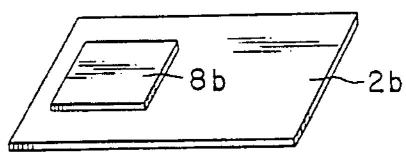
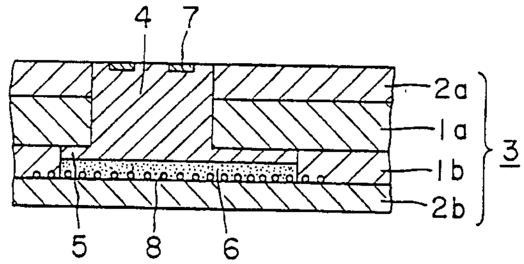
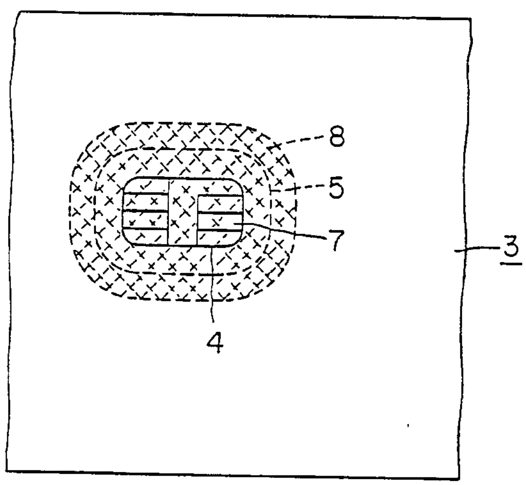


FIG. 27f





F I G. 28



F I G. 29

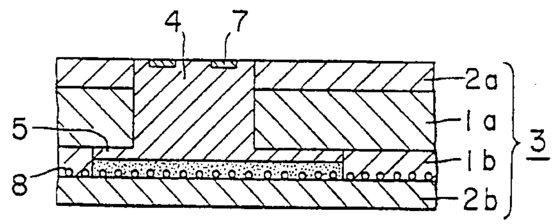


FIG. 30

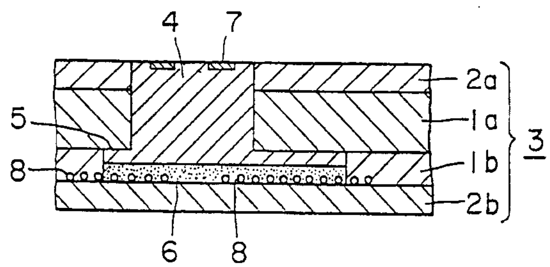


FIG. 31

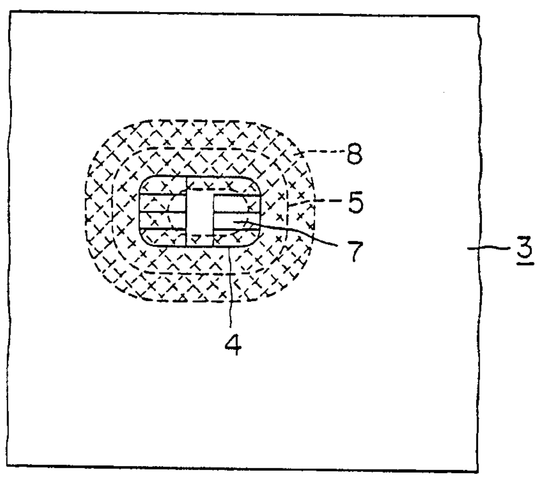


FIG. 32

FIG. 33

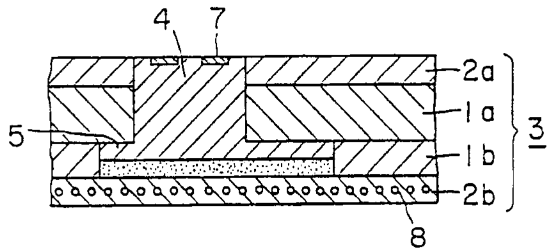


FIG. 34

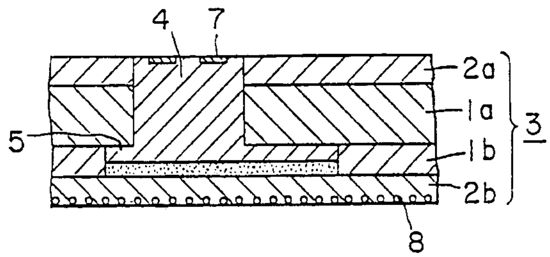


FIG. 35

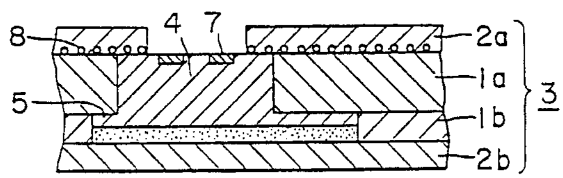


FIG. 36

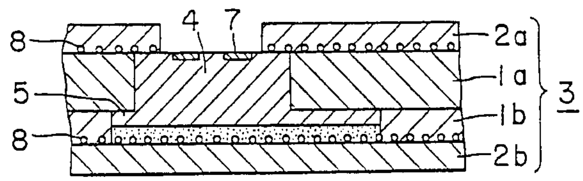
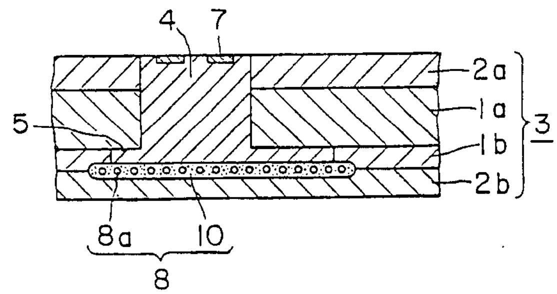


FIG. 37



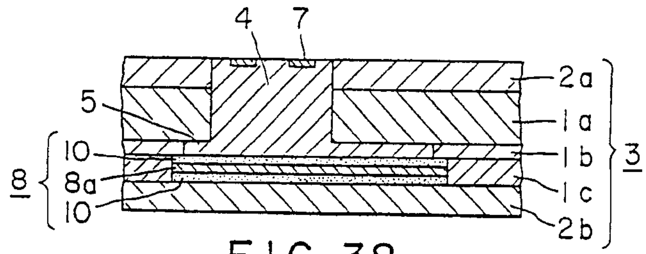


FIG. 38

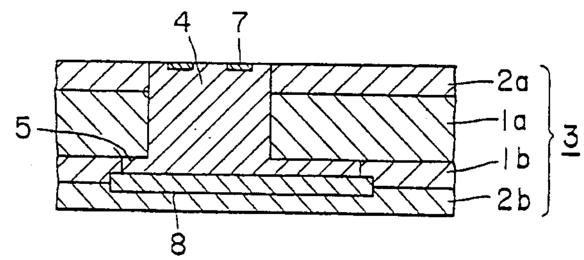


FIG. 39

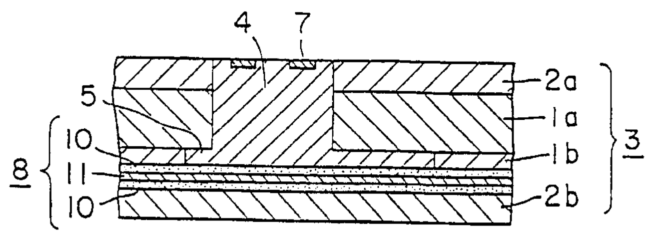


FIG. 40

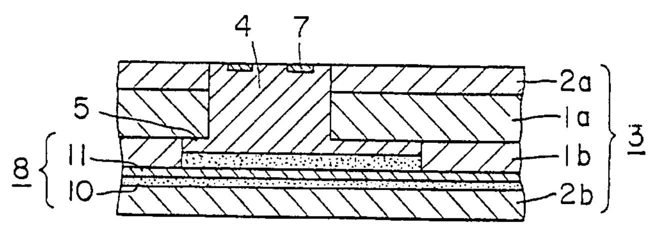
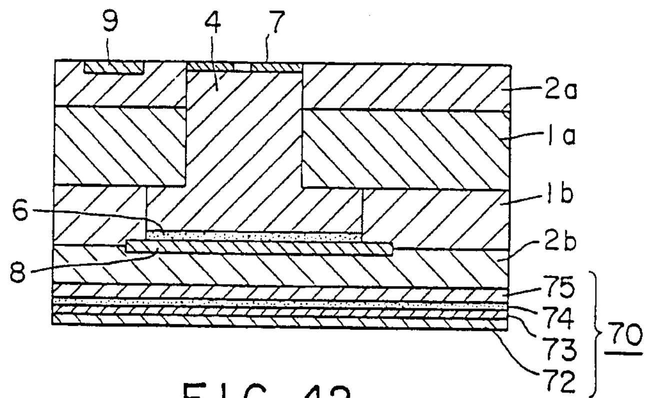
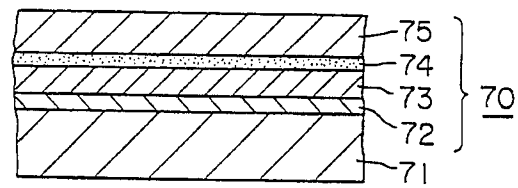


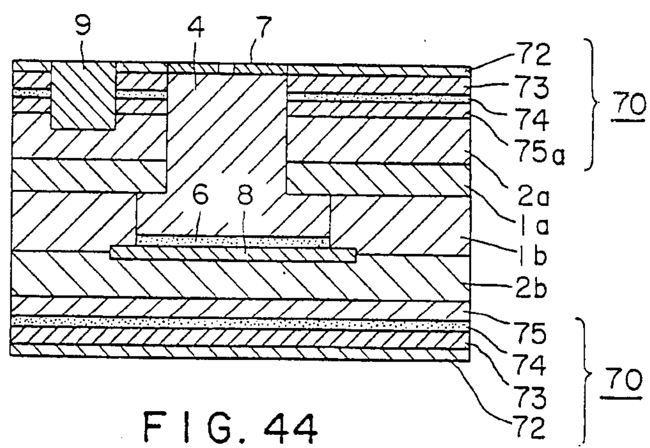
FIG. 41



F I G. 42



F I G. 43



F I G. 44

IC CARD

BACKGROUND OF THE INVENTION

This invention relates to an IC card and an IC module mounted or built therein

In recent years, studies have been progressed about cards called as chip card, memory card, micom card or electronic card (hereinafter referred to merely as IC card) equipped with an IC chip such as microcomputer (hereinafter called MPU), memory, etc.

Such an IC card, due to its greater memory capacity as compared with the magnetic card of the prior art, is intended to memorize the history of deposits and savings in place of a bank book in bank businesses or to memorize the trading history such as shopping in the credit businesses.

Such an IC card generally comprises a center core in the shape of a card in which an IC module is to be embedded and an oversheet for enhancing mechanical strength of the card laminated on one surface or both surfaces of the center core.

Since the IC module built in such an IC card of the prior art is formed of a material having no elasticity, breaks or cracks may form at the boundary portion between the IC module and the card substrate when the card is strongly bent, or in an extreme case the IC module may fall off or become separated from the card.

SUMMARY OF THE INVENTION

The present invention addresses and solves the above drawback. Its object is to provide an IC card with an IC module built there sufficient mechanical strength and flexibility against breakage or cracks during being. In order to accomplish such an object , the IC card according to the first embodiment of the present invention comprises an IC card comprising an IC module embedded in a card substrate, said IC card having a reinforcing sheet layer laid in the planar direction of the card so as to cover at least the peripheral portion of the boundary between the card substrate and the IC module.

Further, the IC card according to the second embodiment of the present invention comprises an IC card comprising an IC module comprising an IC chip, a circuit substrate, etc., embedded in an IC module substrate built in a card substrate, said IC module having a reinforcing member comprising at least a part of the side portion of said IC module substrate extended in the outer circumferential direction.

Also, the IC card according to the present invention may be a combination of the two embodiments as specified above. That is, the IC card of the present invention can be provided with both of the above reinforcing sheet and the above reinforcing member to obtain synergetically excellent mechanical strength and flexibility.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIGS. **1A~1C**, FIG. **28**, FIGS. **30~31**, FIGS. **33~42** and FIG. **44** are each sectional views of the IC card of the present invention;

FIGS. **2**, **29** and **32** are each plan views of the IC card of the present invention;

FIGS. **3** and **4** are each plan views of the IC module to be used in the IC card of the present invention;

FIGS. **5**, **20**, **21**, **23** and **24** are each sectional views of reinforcing sheets (or oversheets);

FIGS. **19** and **22** are each sectional views of reinforcing sheet layers to be produced in accordance with the present invention;

FIGS. **6** and **7** are each plan views of cards comprising reinforcing sheets;

FIGS. **8A~8C** and FIGS. **9~16** are each sectional views of the IC module;

FIGS. **17** and **18** are each plan views of sealing frame layers;

FIGS. **25~27** are each perspective views of construction members of the IC card of the present invention; and

FIG. **43** is a sectional view of a transfer sheet.

DETAILED DESCRIPTION OF THE INVENTION

The present invention is described in more detail below by referring to its preferred embodiments. FIG. **2** is a plan view of an IC card and, in the case of this embodiment, an IC module **4** and a magnetic recording portion **9** are formed in the card. FIGS. **1**A(*a*)~(*d*) are cross-sectional views taken along the I—I line in FIG. **2**, respectively.

More specifically, as shown in FIG. **1**A(*a*), the IC card according to the preferred embodiment of the present invention has an IC module **4** embedded through an adhesive layer **6** in a card substrate **3** comprising a laminate of center cores **1***a*, **1***b* and oversheets **2***a*, **2***b*, and the IC module **4** has a reinforcing member **5** comprising the side portion of the IC module substrate partially extended with respect to the outer circumferential direction. Further, between the center core **1***b* and the oversheet **2***b*, a reinforcing sheet layer **8** is formed by laying e.g., a mesh layer therebetween. The symbol **7** is a terminal for electrical connection to the external device.

The position at which the reinforcing member **5** of the IC module is formed may be provided at the bottom of the IC module as shown in FIG. **1**A(*a*), or otherwise at the middle stage as shown in FIG. **1**A(*b*), or at the upper stage portion as shown in FIG. **1**A(*c*), or further at both the upper stage portion and the bottom as shown in FIG. **1**A(*d*).

Also, the IC module may be shaped so that the reinforcing member **5** may protrude in a specific direction as shown in the plane views of FIG. **3** (FIG. **3**(*a*), (*b*), (*c*) and (*d*), or alternatively shaped in a sword guard (FIG. **3**(*e*)) For obtaining an excellent reinforcing effect, it is preferred that the reinforcing member **5** be formed in a shape so that it may have a greater area toward the portion with a greater flex coefficient of the card.

FIGS. **4**(*a*), (*b*) and (*c*) are examples of IC modules having reinforcing members with such particularly preferable shapes. In FIG. **4**(*a*), the reinforcing member **5** is provided so as to extend out the left and right sides of the IC module **4**, and still have greater area on the right direction side (central portion direction of card). FIG. **4**(*b*) is an example when the reinforcing member is extended in the upper and lower directions, and have a greater area on the lower part direction part.

Further, FIG. **4**(*c*) is an example when the reinforcing member is provided in shape of a sword guard, which is enlarged in the right direction and the lower direction. In these examples, it is assumed that the IC modules are embedded at the position shown in FIG. **2**.

Also, in the IC card of the present invention, a reinforcing sheet layer **8** having a high shear strength and flexibility and/or for high elasticity can be formed by

laying the sheet layer in the planar direction of the card. In this embodiment, it is important that no crack or breaking should occur at the boundary portion between the card substrate **3** and the IC module **4** even when the IC card may be bent under the conditions shown below.

(a) Bending in the longer side direction

At a deflection amount of 2 cm, the card is bent in the face direction and the back direction, respectively, at the rate of 30 times/min. for 100 times or more (preferably 250 times or more).

(b) Bending in the shorter side length At a deflection amount of 1 cm, the card is bent in the face direction and the back direction, respectively, at the rate of 30 times/min. for 100 times or more (preferably 250 times or more)

In order that no crack or breaking should occur at the boundary portion between the card substrate and IC module even in the bending test carried out under the conditions as mentioned above, the reinforcing sheet should preferably be composed of a material having high shear strength and flexibility with recovery when bent or a material having sufficient elasticity capable of absorbing the shearing stress concentrated at the boundary portion between the card substrate and the IC module comprising a rigid body and diffusing its stress when bent under the above conditions. Particularly, materials having high shear strength, flexibility and elasticity may preferably be used.

FIG. **1C** is a cross-sectional view of another embodiment of the present invention. The IC card according to this embodiment has no reinforcing sheet layer but the IC module **4** embedded therein has a reinforcing member **5**. The IC card shown in FIG. **1B** has no reinforcing member in IC module **4** but has a reinforcing sheet layer **8** (e.g., a mesh sheet) laid in the planar direction of the IC card. In this embodiment, the reinforcing sheet layer **8** is laid between an oversheet **2***b* and an IC module **4** so as to cover at least the peripheral portion of the boundary between the IC module and the card substrate.

Reinforcing sheet layer

The reinforcing sheet layer to be laid is not particularly limited in material or shape, provided that mechanical strength and flexibility as mentioned above can be imparted to the IC card. For example, it can be a mesh layer comprising network-shaped sheets as enumerated below, unwoven fabric, continuous sheet, rubber, thermoplastic elastomer, rubbery adhesive layer, tacky layer and others.

(i) Mesh-like sheet

This can be constituted of a knitted or woven fabric in shape of a net or a porous sheet, and as its material, it is possible to use nylon (nylon 66, such as, nylon 6, nylon 11, nylon 610, nylon 4, nylon 7, nylon 9, nylon 12 polyester, acryl, vinylon, rayon, polypropylene, polyvinylidene chloride, polyethylene, polyurea type, polystyrene type, polyurethane type, polyfluoroethylene type (Teflon), etc.; cellulose type such as acetate, triacetate, ethyl cellulose, etc.; semi-synthetic fibers such as chlorinated rubber, hydrochloric acid rubber, etc.; natural fibers such as wool, cotton, silk, etc., glass fiber, carbon fiber, metal mesh or perforated sheets of various plastic films or metals, etc.

By using a reinforcing sheet layer of such a surfaces of the mesh layer can be well fused through the openings of the mesh whereby adhesion therebetween can be easily effected. Also there is also another advantage is that the increase in thickness of the card can be reduced by using the mesh layer. Also, there is no trouble forming embossed letters even when a mesh layer is provided.

(ii) Unwoven fabric

A sheet obtained by arranging fibers according to a suitable method in a thin cotton shape or a mat shape and bonding mutually the fibers through fusion force of an adhesive, etc., can be used.

(iii) Continuous sheet

Metal foil or a plastic sheet such as of polyester, polyimide, polypropyrene, nylon, polyethylene, EVA, acryl, polycarbonate, polyvinylidene chloride, acetate, polyurethane, Teflon, polyvinyl alcohol, polystyrene, etc.

(iv) Rubber sheet

Sheet of natural rubber (NR), styrene-butadiene rubber (SBR), butadiene rubber (BR), butyl rubber, ethylene-propylene-diene-methylene-polymer (EPDM), chloroprene rubber (CR), nitrile rubber (NBR), chlorosulfonated polyethylene (CSM), polysulfide type rubber (T), urethane rubber (U), epichlorohydrin rubber (CHC), acryl rubber (AM, ANN), fluorine rubber (FPM), silicone rubber (SI), etc.

(v) Thermoplastic elastomer

Sheet of thermoplastic SBR type elastomer, thermoplastic polyurethane, etc.

(vi) Rubbery adhesive

Polychloroprene type, nitrile rubber type, regenerated rubber type, butadiene-styrene copolymer (SBR) type or natural rubber type adhesive, etc.

(vii) Adhesive or tacky sheet having an adhesive layer on one surface or both surfaces of sheet substrate:

An adhesive or tacky sheet having a layer of rubbery adhesive, tackifier, thermoplastic resin adhesive, composite adhesive such as polyvinyl formal phenolic, etc., a thermosetting resin adhesive such as epoxy resin, etc., formed on at least one surface of a substrate sheet such as a mesh-like sheet of the above (i), unwoven fabric of (ii), continuous sheet of (iii), rubber sheet of (iv), etc.

The reinforcing sheet layer to be laid may have any desired size and shape, but it is necessary to form the reinforcing sheet layer so that at least the peripheral portion of the boundary between the card substrate and the IC module may be substantially covered.

Reinforcing sheet (**1**)

For example, the reinforcing sheet may be a sheet substrate comprising the above mesh having a network structure formed by laying therein.

As shown in the cross-sectional view in FIG. **5**(*a*), it (**51**) has a mesh **53** as described above laid in a sheet substrate **52**.

For the sheet substrate in this case, a plastic known in the art can be used and may be selected depending on the desired use of the card.

The thickness of the mesh may differ depending on kind of the card or material to be reinforced, but usually a mesh with 10 to 500 μm thickness may be used. The mesh degree (number of mesh openings per 1 inch)

preferably should be 50 mesh/inch or more. If the mesh degree is less than 50 mesh/inch, the mesh becomes weaker in strength (particularly flexural strength), thereby reducing the fracture preventing effect achieved when forming a laminate.

Also, the reinforcing sheet to be used in the present invention may have a fine unevenness formed on the surface of the sheet substrate **52** as shown in the cross-sectional view in FIG. **5**(*b*). Thus, by applying a matte working on the substrate surface, air escape during pressing when preparing a card can be improved, whereby generation of unevenness (so called lick) on the surface can be advantageously prevented.

Such a reinforcing sheet can be prepared according the methods as described below.

(a) Method by hot press

For example, there is the method in which a mesh is embedded into plastic sheet by carrying out hot press with a mesh sandwiched between two sheets of plastic sheet, or the method in which a mesh is embedded within a plastic sheet by carrying out hot press with a mesh placed on one surface of one plastic sheet.

(b) Laminating method by use of an adhesive

For example, there is the method in which a mesh coated with an adhesive is sandwiched between two sheets of a plastic sheet and a pressure is applied thereon. The adhesive available in this case may include those known in the art such as rubber type adhesive, tackifier, thermoplastic resin adhesive, composite adhesive, thermosetting resin adhesive, etc.

(c) Further, a method which combines the above methods (a) and (b) may also be used.

Reinforcing sheet (2)

When the mesh sheet is laid on the whole surface of the card substrate, it may be laid so as to cover the whole surface in the planar direction of the card as shown in the plan view of FIG. **6** (FIG. **6**(*a*)), or alternatively it may be formed so as to give brims at the peripheral portion thereof (FIG. **6**(*b*)).

Further, as shown in FIG. **7**, by laying the mesh so that the direction of the network of the mesh may be slanted relative to the side of the card, there are advantages that (a) the bending strength of the card can be further improved, and also that (b) no fray of the mesh will come out from the cut face when it is punched out into a card size in the final step.

The sharp angle α between the direction of the fiber constituting the network of the mesh and the side of the card in this case may be within the range of $0<\alpha<90°$, preferably $10°<\alpha<80°$, and more preferably α=about 45°.

The thickness of the mesh may differ depending on the kind of the card or the material to be reinforced, but it is preferably 10 to 500 μm. The mesh degree (number of openings per 1 inch) should preferably be 50 mesh/inch or more. If the mesh degree is less than 50 mesh/inch, the strength (particularly flexural strength) becomes weaker.

Reinforcing sheet (3)

The IC card of the prior art involves the following problems, namely:

(a) the resin material used in the mold of IC module of the prior art is generally black, and besides the oversheet is constituted of a transparent material, whereby on the back face of the IC card (namely the face on the side opposite to the terminal for connection) the shade of the IC module portion can be seen, this creating a great obstacle when forming visible information such as printing on the back face of card and also causing the problem of lowering aesthetic characteristic of the card; and

(b) since the existence of an IC module can be easily grasped from the back face side of the IC card, it is also disadvantageous in prevention of forgery, of card.

To avoid the above problems, an embodiment is characterized by having an opaque white oversheet laminated through a reinforcing sheet which also functions as the shielding layer on the face opposite to the terminal for connection of the IC module.

Such a shielding layer may also function as an adhesive layer. For example, the shielding layer may be formed of an opaque white sheet such as a white polyester and adhesive layers laminated on both surfaces thereof. The shielding layer may have a color identical or similar to that of a card substrate and/or an IC module.

Further, in this case, for enhancing the shielding effect, the component materials of an IC module, for example, the material of an IC module or the resin for its mold can be made of materials having a color identical or similar to those of a card substrate (e.g., opaque white).

Reinforcing sheet (4)

In this embodiment, the reinforcing sheet (adhesive sheet) has polyolefin type adhesive layers laminated on both surfaces of the plastic film. The kinds of the adhesive layers on both surfaces may be either the same or different.

As the plastic film, a polyester, polycarbonate, cellulose type polyimide film, etc., may be used, but in respect of reinforcing effect, a polyester film is particularly preferred. The plastic film may have a thickness preferably within the range of from 3 to 50 μm. If the thickness is less than 3 μm, a good reinforcing effect cannot be obtained, while a thickness over 50 μm is disadvantageously too thick.

As the material for the adhesive layer in type hot adhesive may be preferably used especially an ethylene-acrylic acid copolymer adhesive, and ethylene-vinyl acetate copolymer adhesive. The thickness of the adhesive layer may be 1 to 80 μm in view of obtaining good adhesive force and giving no disadvantage to the card thickness.

In addition, by making the plastic film opaque white or a color similar to that of the IC module, there is created the effect of shielding the shade of IC module portion when the IC card is observed from the backside, whereby printing and aesthetic characteristic on the backside of the card as well as the effect of preventing forgery can be improved. As the method for whitening, there may be employed the method in which a white pigment is kneaded into a film material or the method in which a white layer is separately coated.

IC module (1)

Next, a specific example of an IC module to be built in the IC card of the present invention is described together with its preparation example.

FIG. **8A** is a sectional view of the IC module according to one embodiment.

First, on the surface of an IC module substrate **31** comprising a glass epoxy film with a thickness of about 0.1 mm (film prepared by impregnating a glass cloth with an epoxy resin and curing the resin), etc., an electrode pattern **32** for connecting terminal with a thickness of 30 μm is formed. The electrode pattern **32** can be formed by patterning to a desired pattern according to photoetching by use of a film having a copper foil laminated on the IC module substrate layer **31**, and then applying Ni and Au plating thereon.

Subsequently, a circuit pattern layer **33** having a hole for arranging an IC chip and at least two layers of circuit patterns formed thereon is prepared. This circuit pattern layer **33** can be formed by using, for example, an insulating film (e.g., glass epoxy film) having copper foils formed on both surfaces thereof with a thickness of about 18 μm to form circuit patterns **33***a*, **33***b* in two face and back layers by patterning to desired circuit patterns according to photoetching, etc., and further providing a through-hole **33***c* for taking conduction at a desired position between the face and back circuit patterns **33***a* and **33***b*.

For formation of the through-hole **33***c*, first the portions other than the through-hole working portion are covered with a resist and subsequently, hole-opening working at the through-hole portion, plating working internally of the through-hole and removal of resist are performed in this order.

After formation of the through-hole, Ni plating and Au plating are applied at the circuit portion.

After plating of the circuit portion, the resist is removed and hole-opening working is performed at the portion where IC chip is to be provided.

Next, with registration between the IC module substrate layer as prepared above and the circuit pattern layer, the respective layers are plastered through an adhesive layer **34** to be integrated. The plastering step may be also conducted by hot pressure adhesion through, for example, semi-cured epoxy resin film.

Subsequently, for conduction between the electrode pattern **32** for connecting terminal and the circuit pattern **33***b* in the circuit pattern layer **33**, a through-hole **32***a* is provided at a desired position. The through-hole **32***a*, can be formed in the same manner as formation of the above through-hole **33***c*.

As the next step, a sealing frame layer **35** is prepared for prevention of flow-out of the resin during resin molding of IC module. In this embodiment, the extended portion of the sealing frame layer **35** constitutes the reinforcing member (in FIG. **8**A, having greater area in the right direction). The sealing frame layer **35** is formed by providing minimum extent of holes for exposing circuit portion for wiring an IC chip on an insulating substrate (thickness about 0.2 mm) of the same material as used for the above IC module substrate layer and the circuit pattern layer.

Then, the above sealing frame layer **35** is plastered through an adhesive layer **34** where the circuit pattern **33***b* of the laminated of the above IC module substrate layer and the circuit pattern layer is formed to be integrated. It is also possible to form an adhesive layer on the extended portion of the sealing frame layer **35** constituting the reinforcing member.

On the circuit substrate for IC module thus prepared, an IC chip **36** is mounted by use of an adhesive **34**. More specifically, as shown in FIG. 8A, the IC chip **36** becomes supported on the IC module substrate layer **31**. Next, the bonding portion **37** of the IC chip is connected to the circuit pattern **33***b* with a conductor **38** according to the wire bonding system, etc. This may be also practiced according to the face-bonding system without use of a wire and, in that case, a thin IC module can be obtained. After wiring between the IC chip **36** and the circuit pattern **33***b* is effected, molding is carried out by filling a resin for mold **39** such as an epoxy resin, etc., so as to cover the IC chip and the wiring portion. During molding, the surface of the resin **39** is made to coincide in height with the surface of the sealing frame layer **35**. By curing of the mold resin, formation of IC module having a reinforcing member is completed.

It is also possible to constitute a reinforcing member by extending the IC module substrate layer **31** according to the same method as described above (FIG. **9**), further possible to constitute a reinforcing member by extending both of the IC module substrate layer **31** and the sealing frame layer (FIG. **10**), and further an embodiment of extending the circuit pattern layer **33** can be used (FIG. **11**). In any of the above cases, an adhesive layer may be formed on the surface of the extended portion constituting the reinforcing member.

Everyone of the above examples is an example of using a single IC chip, but a reinforcing member can be also constituted according to the same embodiment as the above FIG. **8**A for an IC module having a plurality of IC chips built therein. For example, FIG. **12** is an embodiment of the case when an IC module corresponding to FIG. **8**A was formed with two-chip constitution. Also in this embodiment, it is possible to form an adhesive layer on the extended portion of the sealing frame layer constituting the reinforcing member.

FIG. **13** is an embodiment when the IC module is constituted with two-layer constitution and different from the three-layer constitution as shown in FIG. **8**A ~ FIG. **12** in that no circuit pattern layer **33** is employed. The embodiment shown in FIG. **13** constitutes the reinforcing member (extended portion) with the sealing frame layer **35**, but alternatively a reinforcing member may be formed by extending the IC module substrate layer **31** as shown in the above embodiment in FIG. **9**. Also in this case, an adhesive layer may be formed on the surface of the extended portion constituting the reinforcing member.

IC module (2)

The IC module shown in FIG. **14** is a modification of the IC module shown in FIG. **12**.

That is, in this specific embodiment, the reinforcing member **35***a* is formed by extending the sealing frame layer **35**. And, this reinforcing member is extended toward the outer circumferential portion so that a stepped difference may be formed at the sealing frame layer **35**. Therefore, as compared with the case when no such stepped difference is provided, the stress imposed on the bonded portion (**34**) between the circuit pattern layer **33** and the sealing frame layer **35** can be reduced, whereby mechanical strength and flexibility against bending of the IC module can be further enhanced. Such a stepped diference can be formed by cutting working, etc.

The embodiment shown in FIGS. **15**A and **15**B is another modification and, in this case, the reinforcing member **33***d* is formed with provision of a stepped difference at the circuit pattern layer **33**.

Other than those as described above, as shown in FIG. **15**C, a reinforcing member having a stepped dif-